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HIGH CURRENT 270 VDC CONTACTOR AND CURRENT SENSOR SYSTEM DESIGN AND DEVELOPMENT

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13. ABSTRACT *(Maximum 200 words)*

The work reported in this document is the High Current 270 Volt direct current (Vdc) Contactor and Current Sensor System Design and Development Program. This report covered the entire program from the conceptual design through Preliminary design Review (PDR) phase, Critical Design Review (CDR) phase, and the Acceptance Testing (ATP).

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PREFACE

This is the final report for the "High Current 270 Vdc and Current Sensor System Design and Development" presenting the work performed by Eaton Corporation, Aerospace Controls Division, Sarasota, Florida, under Air Force Contract No. F33615-93-C-2359, Data Item No. A004. The work was sponsored by the Air Force Research Laboratory, Wright-Patterson Air Force Base, Ohio, Mr. John Nairus, AFRL/PRPE, was the Project Engineer.

The work reported in the main section of this document was performed in response to the coordination effort and a number of design and program reviews between Eaton Corporation, Aerospace Controls Division, Northrop-Grumman, and the Air Force Research Laboratory during the period of October 1994 through August 1998.

The Program Manager was Dennis Timm, Project Engineers were Sean Sande, Karl Kitts, and Robert Shanebrook - Technical Data Coordinator was Tuan N. Tran.

SECTION 1

EXECUTIVE SUMMARY

Eaton Corporation executed and completed the High Current 270 Vdc and Current Sensor System Design and Development program under Contract Number FY1455-93-01702. Eaton Corporation has designed, developed and tested a magnetically latched contactor that met the following performance characteristics:

1. Electrical Life of 50,000 operations each direction at 270Vdc, 500 Amps, L/R = 3ms

2. Electrical Life of 5,000 operations each direction at 270Vdc, 1000 Amps, L/R = 3ms

3. Rupture, 10 operations each direction at 350Vdc, 45000 Amps, L/R = 3ms

4. Device includes a shunt type current sensing system (+/-7% accuracy) with trip functions in accordance with I^2t trip curves per Charts 1 and 2 of section 2. The device also includes control functions per the logic diagram shown in Figure 1 of Section 2.

SECTION 2

INTRODUCTION

2.1 Background

Eaton Corporation, Aerospace Controls Division, Sarasota Plant has been involved in the development of 270 Vdc technology for over 14 years. This research has led to the design of a small, lightweight, bi-directional, 250 Ampere contactor compatible with various electronic current sensing, voltage sensing, and controls functions.

During 1988 and 1989, Eaton Corporation, Aerospace Controls Division, Sarasota Plant, designed and developed the first hermetically sealed 270 Vdc, 250 Ampere contactor for an advanced military aircraft. The application called for bi-directional switching of power within the aircraft, current sensing, and other various electronic control functions. As a power controller, this single device was required to provide the following combined electrical performance:

300 Vdc at	250 Amperes --	50,000 operations
350 Vdc at	250 Amperes --	500 operations
475 Vdc at	250 Amperes --	10 operations
475 Vdc at	1500 Amperes --	2 operations

The unit was designed for this application and met all the electrical requirements including 25 operations at 475 Vdc, 1500 Amperes rupture current. Overall package size was approximately 5.0 X 4.5 X 4.0 inches with a weight of approximately 4.5 pounds including electronics. The size of the actual mechanical switching area and magnetically latched solenoid measured only 4.0 X 2.5 X 1.8 inches.

Temperature rise was also an issue due to the electronics being packaged within the contactor housing. A maximum junction temperature requirement necessitated that the contactor design should be such that the units' temperature rise would not exceed 30 °C. Actual temperature rise of the Eaton designed contactor measured around 20 to 25 °C at 300 Vdc, 250 Amperes, continuous carry.

The accomplishment that Eaton achieved from this program has established Eaton's leadership in the design of 270 Vdc power contactors. Since this program, Eaton Corporation, Aerospace Controls Division, Sarasota Plant, has provided contactors for other prototype 270 Vdc, 250 Amperes, power systems including work being done on the Air Force's Power Management and Distribution for the More Electric Airplane (MADMEL) program.

2.2 Objectives

The objective of this program is to design, fabricate, and test a magnetically latched coil design, high current 270 Volt Direct Current (Vdc) contactor and current sensor system. The specific system design goals are as follows:

a. Contactor – Design, Fabricate, and Test a contactor with the following attributes:

- 270 Vdc in accordance with MIL-STD-704E.
- Contactor capable of carrying and breaking circuit regardless of direction of current flow (Bi-directional).
- The motor to be magnetically latched.
- The contactor to be capable to make, break, and carry 500, 1000 Amperes with a three millisecond L/R time constant.
- Contactor electrical life shall have a rupture capability of 4.5 k Amperes at 350 Vdc, 10 operations minimum each direction.

b. Current Sensor – Design, Fabricate, and Test a current sensing system with the following attributes:

- Repeatable accuracy of +/- 7%.
- The Trip functions in accordance with I^2t trip curves per charts 1 and 2.
- The Control functions per the logic diagram shown in Figure 1.

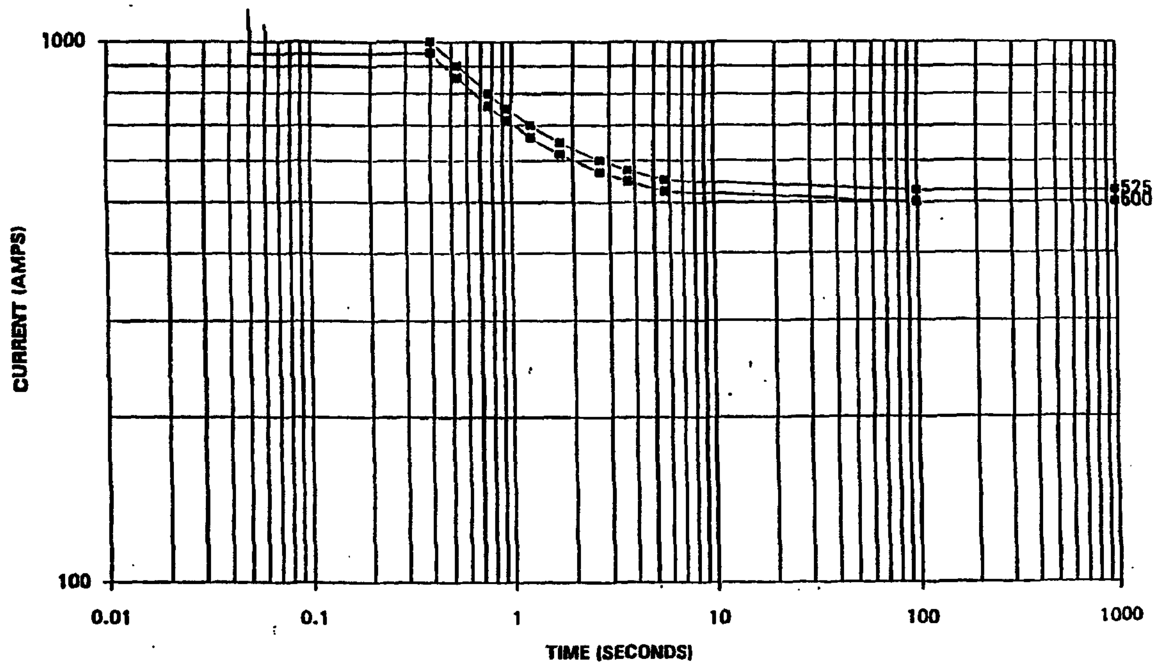
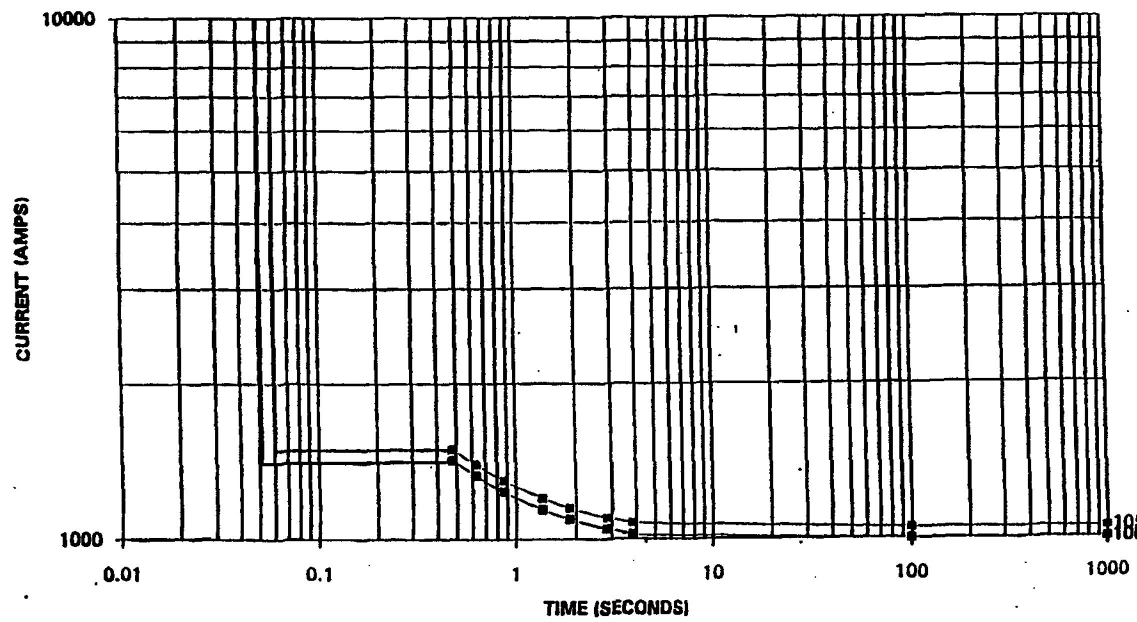


Chart 1. I^2t Trip Curve for the 500-Ampere Device



I = ±2.5%

Chart 2. I^2t Trip Curve for the 1000-Ampere Device

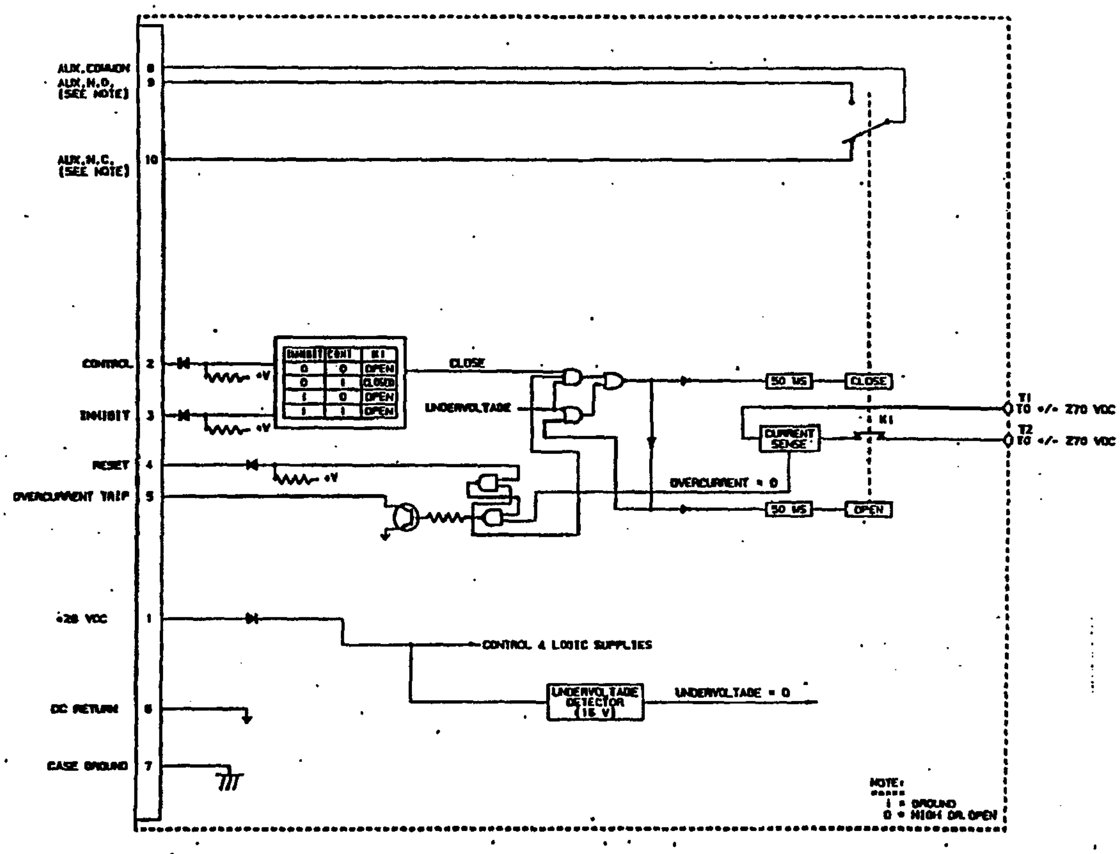


Figure 1. Logic Diagram

2.3 Approach

The Eaton 270 Vdc contactor design approach was to utilize several features that permit high performance switching in a package of minimum weight, relatively small product size, and at competitive costs. This design approach also provides for the incorporation of electronic current sensing and control functions that might be needed in the final application. The design was hermetically sealed for use by high performance aircraft employing high voltage power systems.

2.3.1 Splitter Plate Chute Design

In order to interrupt a dc circuit, the switching device must develop a voltage in opposition to and greater than the system voltage. This reverse voltage must be developed reliably and maintained stable until the current reaches zero.

For this specific application, the worst case switching condition is the rupture rating of 35 Vdc, 4500 Amperes. A reverse voltage of 400 to 450 volts is sufficient to successfully interrupt this rupture load with minimal degradation to the switching device.

In an air-break design, such as that proposed, the reverse voltage is developed by means of the arc, namely the arc voltage. The key issue is how to develop a stable 400 volt arc voltage in the smallest possible package.

The 400 volt arc can be developed through the simple elongation on the arc by mechanically stretching or magnetically driving it. If the arc is only loosely confined, an arc voltage of approximately 50 volts per inch of arc length can be achieved. The resulting 8-inch arc would be difficult to contain in a small package.

The 400 volt arc can be achieved by splitting a long arc into many shorter arcs in series. A short arc (0.04 to 0.08 inches long) between metal electrodes has an arc voltage of approximately 25 to 30 volts. This arc voltage is essentially independent of current level. The series combination of many short arcs, by means of a splitter plate chute, Figure 2, results in an arc voltage as high as 300 volts per inch of length.

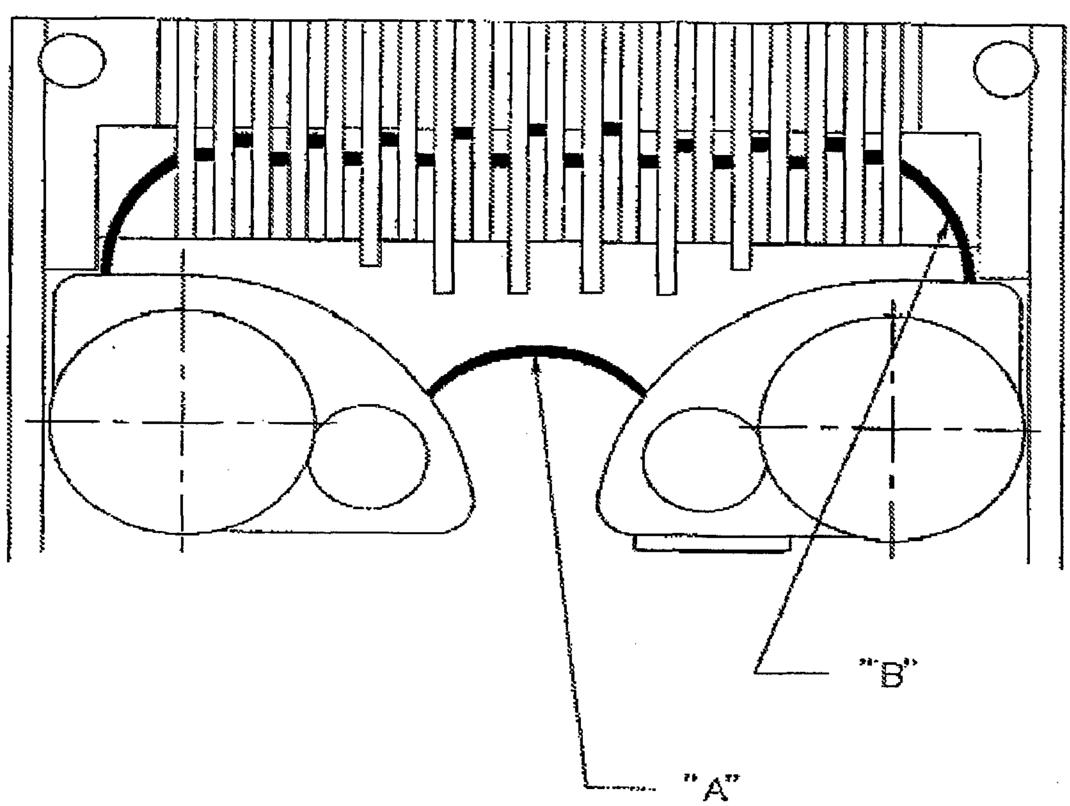


Figure 2. Arc Splitter Plates

A. Arc established between arc runners and advancing toward arc splitter plates.
B. Arc in final position between splitter plates just prior to current dropping to zero.

2.3.2 Magnetic Structure Design

The next key step in the design is to provide a means, independent of polarity, to reliably and stably move the arcs that form between opening contacts, into the splitter plate chute.

When the circuit is opened, two arcs are formed. One arc is in each of the two arc chambers, between its respective stationary and movable contact. These arcs are acted upon by the magnetic field established by the magnets on the outside of each arc chamber. The magnetic field across each arc chamber is essentially normal to the arc. Figure 3 shows one of the two arc chambers with the magnetic field superimposed. A return ferromagnetic flux path maximizes the level and optimizes the shape of the magnetic field. This magnetic field is in opposite directions in the two arc chambers. The direction of current flow through the device determines which arc chute is the active arc chute thus providing for bi-directional operation of the contactor.

The level and shape of this magnetic field is extremely critical to the performance of the switching device. The field level must be sufficient to reliably move the arc from the contact gap up to, and into the splitter plate chute. The field shape must be such that the arc motion is smooth and consistent with a characteristic to hold the arc in its final rest position.

2.3.3 Summary

The incorporation of a splitter plate chute and magnetic arc control provides maximum switching capability in the smallest possible package size. By using a combination design as described, problems such as back striking (the remake of circuit between the breaker contacts) and arc blow through (a condition where the arc advances past the splitter plate chute area) are eliminated.

That was the logic behind Eaton Corporation using the Splitter Plate Chute and Magnetic Structure Design approach. This design approach has been developed and proved by Eaton Corporate Research and Development Center.

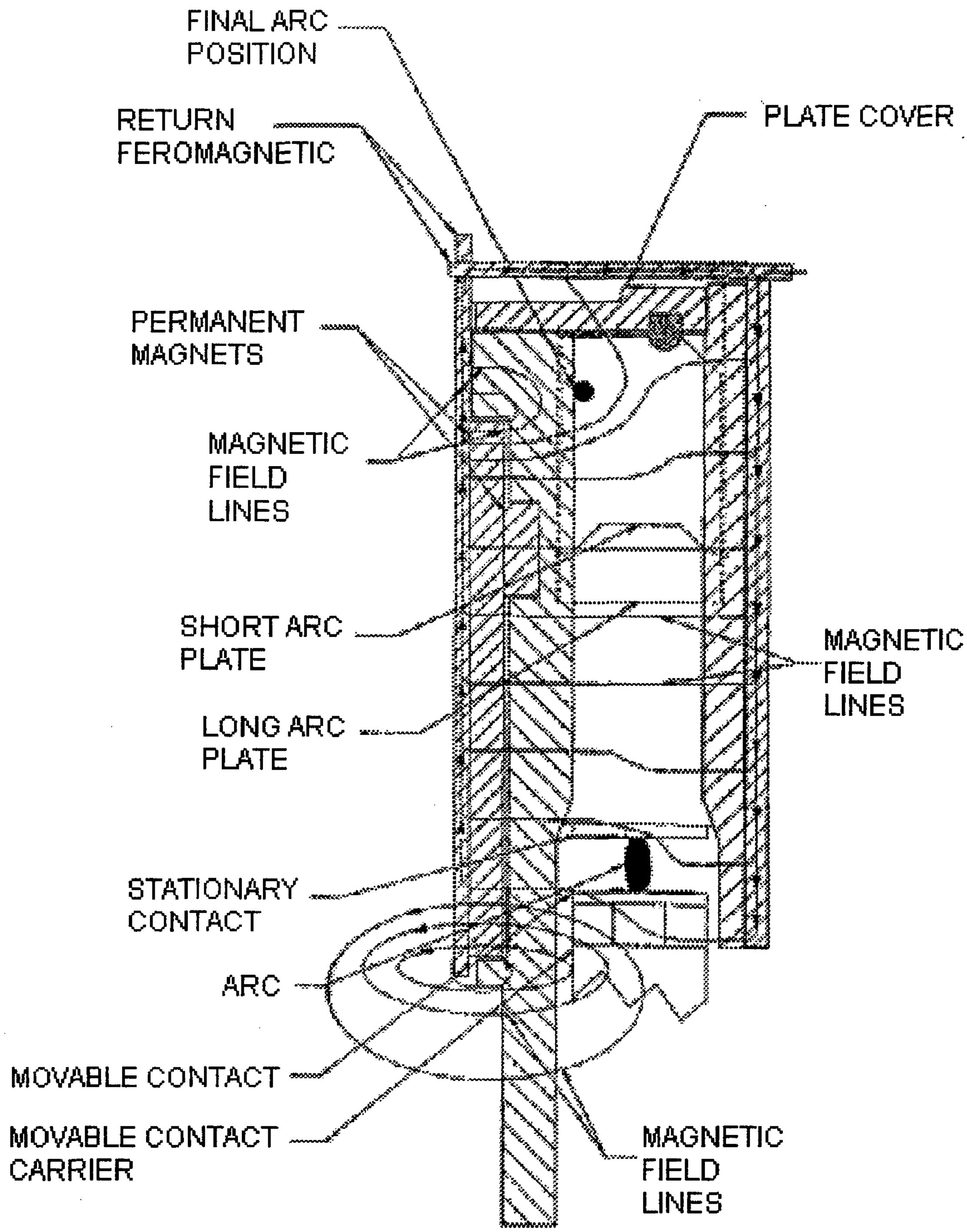


Figure 3. Arc Chute Magnetic Field

SECTION 3

HIGH CURRENT 270 Vdc CONTACTOR AND CURRENT SENSOR SYSTEM DESIGN AND DEVELOPMENT

3.1 System Design and Development

In order to satisfy the objectives of this program Eaton Corporation has used the results of many years of research in the areas of materials, magnetics, arc science, and electronics in order to identify the technologies used in the design of the HVDC contactor. Eaton Corporation has developed a design, completed a critical design review, developed a test plan, constructed the prototype test units, and carried out the testing. This final report constitutes the final deliverable under the Air Force contract.

3.1.1 Splitter Plate Design

Several characteristics are considered in the design of arc splitter plates for a contactor. These include the number of splitter plates required, the thickness of the plates, the distance between plates, plate lengths, front edge configuration, end plate distance to housing, and end plate distance to the arc runners. The maximum specified system voltage and the various current requirements of the device affect all of these elements.

The number of splitter plates is dependent upon the maximum system voltage and the reverse voltage that is developed by an arc formed between each set of splitter plates. Since the maximum system voltage for this design project has been established at 350 Vdc, and it is developed by an arc between one set of splitter plates, one can calculate the number of plates at 14. With 14 splitter plates, a maximum reverse voltage of up to 450 Vdc can be developed thus providing the necessary reverse voltage to break the circuit.

The thickness of the splitter plates is determined by system current. Sufficient thickness must be provided to allow for erosion of the splitter plates by the arc during the life of the device. Splitter plate thickness for the device under design has been established based upon experience and the condition of the splitter plates in the 250-ampere base design after testing.

The distance between plates, staggered plate lengths, front edge configuration, end plate distance to housing, and end plate distance to the arc runners are characteristically determined by the strength of the arc. Proper design of these items insures that the arc enters the splitter plates freely with minimal resistance. If the arc resists movement into the splitter plates, the formation of the required reverse voltage will take longer and result in excess erosion of the splitter plates. The sizes reported herein have been established based upon experience.

3.1.2 Arc Runner Design

Factors affecting the arc runner design include throat gap, nose radius, included angle of ~90-120 degree between the two arc runners, and the wall to wall gap. These factors are related to the arc size generated during break of the rupture current and are configured to permit free arc movement into the splitter plate chute. Restriction of the arc results in slow formation of the reverse voltage required to extinguish the arc. At this time it is anticipated that the nose radius and included angle between the two arc runners in the device will remain the same as in the base 270 Vdc, 250-ampere unit. This assumption is made based upon preliminary sketches that show that the arc plates can be placed such that changes in these two characteristics will not be required. The throat gap and wall to wall gap will have to be increased approximately 40% to permit free movement of the arc.

3.1.3 Magnetic Structure Design

The magnetic field established in the splitter plate chute area must be maintained for all voltage/current levels. Since the strength of the magnetic field changes proportionately with distance, the 40% increase in wall to wall distance, required for free movement of arc, will require that the thickness of the major and minor magnets in this design be increased by 40%. This change in individual magnet strength requires that the magnetic steel members cross sectional area also be increased by 40% to avoid magnetic saturation. Reference Table 1.

3.1.4 Contact Design

To accommodate the current rating of this device, the contacts will be larger in size, approximately 40% over the base unit described above. The contact material will consist of 85% silver and 15% cadmium oxide. It has also been determined that the contact gap for this device be set at 0.140 inches with a 0.060 inch wear allowance. Additional calculations and modeling must be done to establish the final contact force. Contact force affects contact resistance which in turn affects unit heating. Since this unit will contain electronics for the current sensor and control functions, unit heating becomes an important issue. Reference Table 1.

Information from our Corporate R&D (CORD) facility in Milwaukee offered the followings: "Contact resistance is in general proportional to 1/(square root of the contact force). Which means, if one wants the same millivolt drop at, for instance double the current, the contact force would have to be increased by four times. The real determiner of contact force will be the watts or power that can be dissipated out of the wires and the device at the higher currents. If we assume that the ability to dissipate heat increases linearly with the increase in current rating, then we need to target a 4-fold increase in contact force for 500 amperes, a 16 fold increase for 1000 amperes and a 36-fold increase for 1500 amperes as compared to the base unit, which has a contact force of 5.0 to 5.25 pounds. This whole scenario, we think, is too high of a contact force and that the ability to dissipate heat actually increases more than linearly with the increase in current rating."

3.1.5 Current Carrying Members

Due to the inclusion of electronics in the base unit, it was necessary to maintain a low temperature rise to prevent the junction temperature of the electronics from exceeding 110 degrees Celsius. A temperature rise of 20 to 25 degrees Celsius was obtained, with base unit carrying full rated load, by designing the current carrying members with a current density of 1000 amperes per square inch or less. Since this unit will also contain electronics for motor control and current sensing, the same design criteria will be followed. Reference Table 1.

DESIGN FEATURE	BASE UNIT 250 Ampere 475 Vdc Max. 1500 Ampere Rupture	500 Ampere 350 Vdc Max. 1500 Ampere Rupture	1000 Ampere 350 Vdc Max. 3000 Ampere Rupture
ARC PLATE THICKNESS	0.040	0.040	0.062
ARC PLATE SPACING	0.045	0.045	0.062
NUMBER OF PLATES	20	14	14
PLATE LENGTH	0.614	0.614	0.798
PLATE FRONT EDGE SHAPE	As shown Figure 4	As shown Figure 4	As shown Figure 4
CONTACT GAP	0.110	0.110	0.140
CONTACT WEAR ALLOWANCE	0.040	0.040	0.040
ARC RUNNER THROAT GAP	0.301	0.301	0.361
ARC RUNNER NOSE RADIUS	0.092	0.092	0.092
ARC RUNNER TO ARC PLATE GAP	0.100	0.100	0.200
END ARC PLATE TO HOUSING GAP	0.194	0.194	0.233
DEFFERENTIAL LENGTH BETWEEN LONG AND SHORT ARC PLATES	0.145	0.145	0.218
MAGNET THICKNESS	0.100	0.100	0.120
MAGNETIC STEEL THICKNESS	0.042	0.042	0.051
WALL TO WALL GAP	0.457	0.457	0.548
POWER STUD FASTENER SIZE	¼ - 20	¼ - 20	3/8 - 24
POWER TERMINAL DIA.	0.620	0.836	1.188

Table1

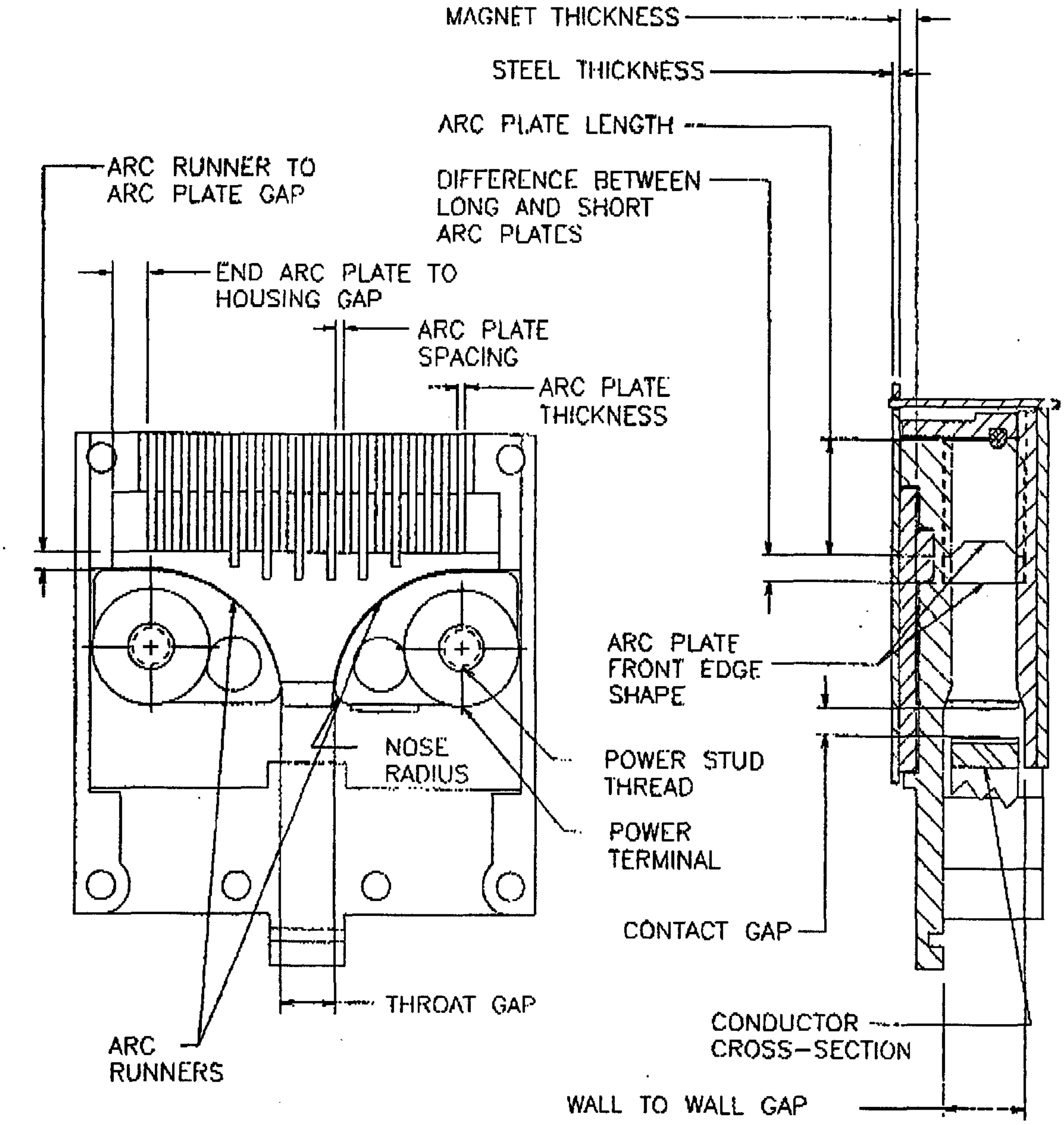


Figure 4. Component & Sizing Drawing

3.2 Arc Interruption in the Final Design

Arc interruption in the device is completed only if the following two circumstances occur.

1. The device upon opening generates enough back emf in the arc column and arc splits to match or exceed the source.

2. The device maintains the back emf long enough to dissipate the energy stored in the reactive elements of the circuit.

Below is a voltage / current trace, which when analyzed closely paints a picture of what happens from the time the contacts first open to the time when the current goes to zero and the voltage across the device returns to system open circuit voltage levels.

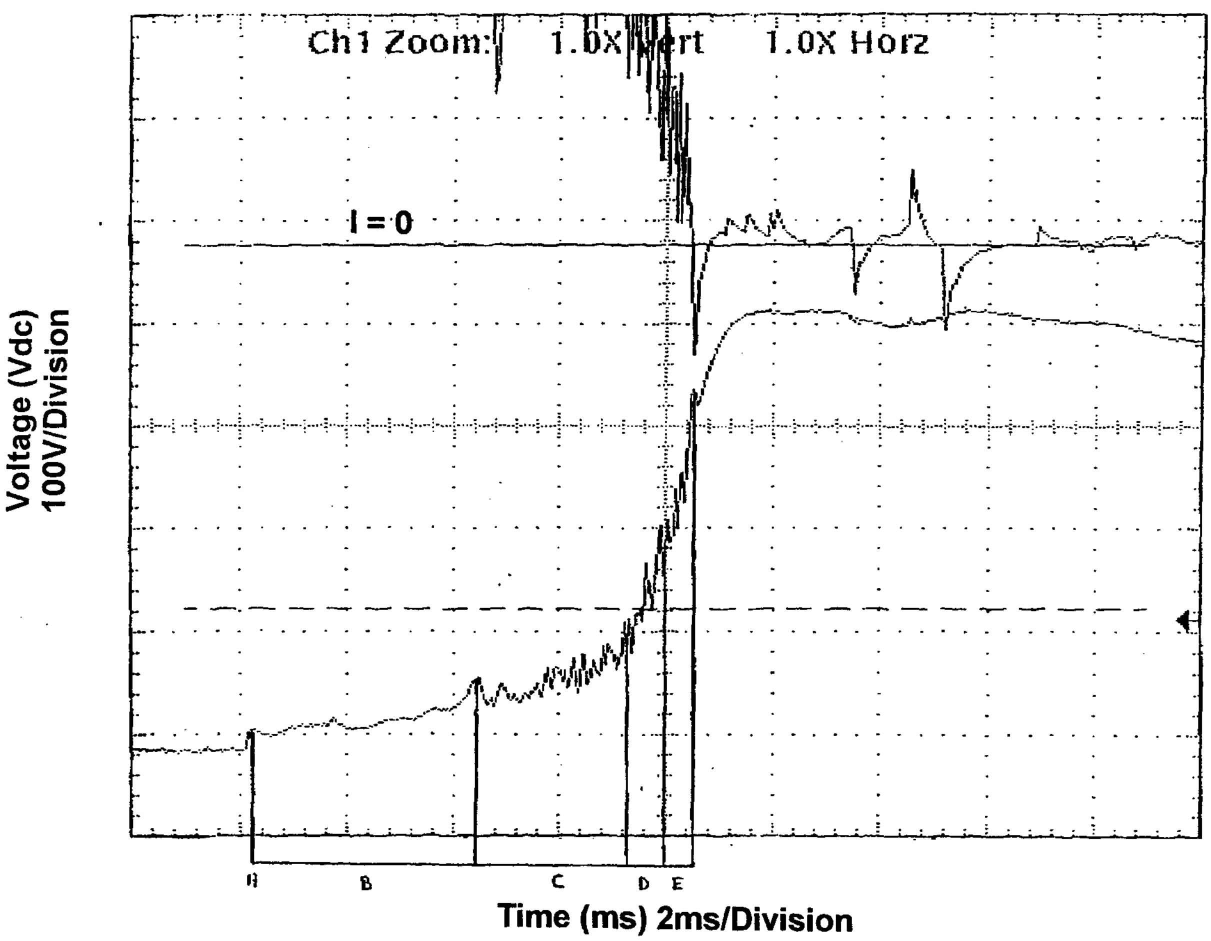


Figure 5. Voltage / Current Trace Chart

Initially, an arc is generated across both sets of contacts, as shown in Figure 6 and depicted in the voltage trace at point A, Figure 5. Here the back emf generated is equivalent to the voltage drop in the two arc columns, the two anode drops, and the two cathode drops. This equates at this point to about 24 Vdc or 12 volts per split.

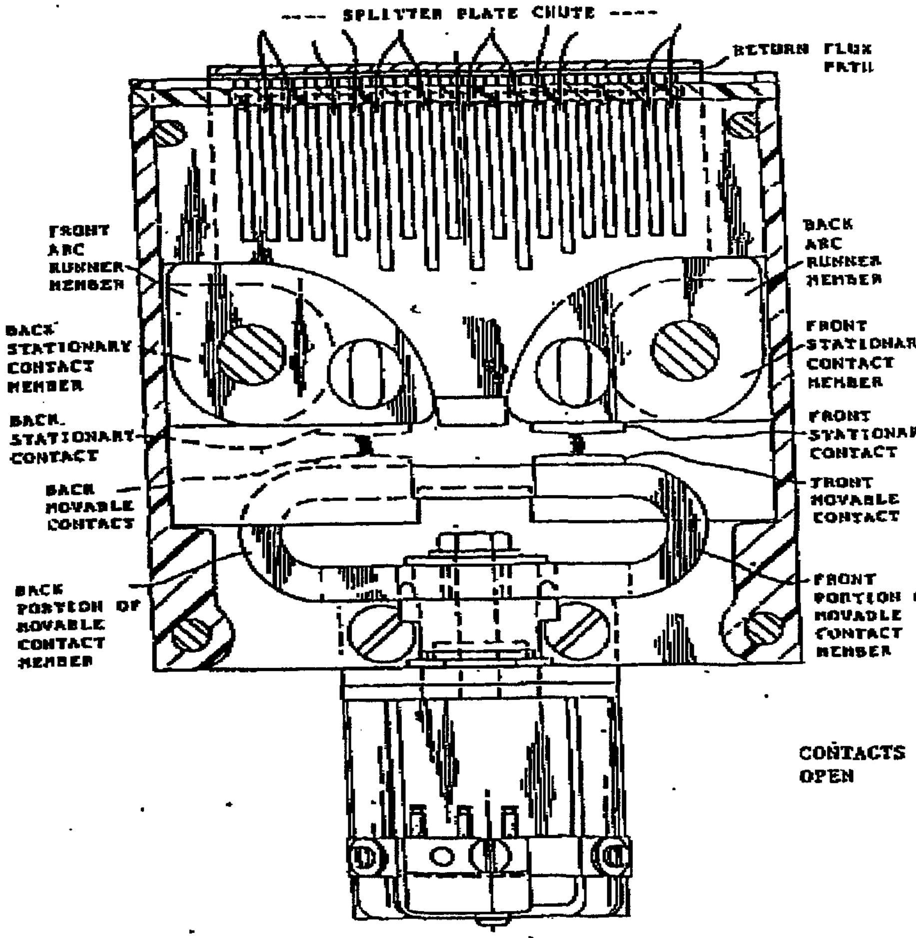


Figure 6. Open Contact Drawing

During Section B in the voltage trace, the arc columns begin to move, due to the magnetic field imposed across the arc chute and the self-field generated at the root of the arc as shown in Figure 7. Notice that one arc moves toward the center of the arc chute while the other moves to the side of the arc chute. Since this unit is a bi-directional device, if the current direction were reversed, the direction of arc travel, as shown in Figure 7, would be opposite. Notice the gradual rise in arc voltage on the voltage trace in Section B as the two arc columns are forced to become longer thereby increasing the arc voltage in the arc column component of the total back emf generated. The arc moving toward the center of the arc chute is referred to as the switching arc, and the arc moving off to the side is referred to as the nuisance arc. Once the switching arc moves far enough to the center of the arc chute it then commutates from the movable to the opposite stationary, thereby, shorting out the nuisance arc.

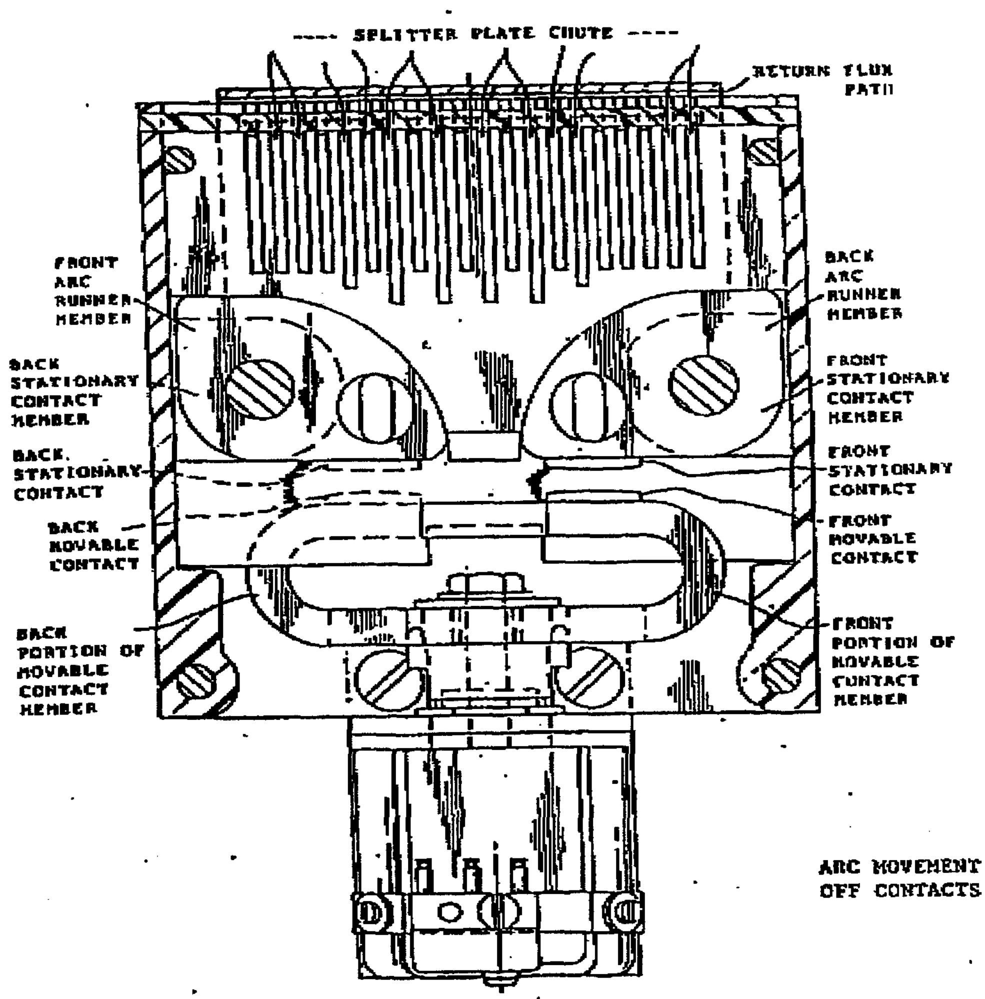


Figure 7. Arc Movement off Contacts

In order for the switching arc to commutate from the movable to the stationary, the arc has to be able to exist at this point at a lower voltage than what exists when both the switching and nuisance arcs are present, as shown in Figure 8. This is consistent with the minimum arc voltage principle. As can be seen in the voltage trace in Section C, the voltage drops slightly when the switching arc bridges the gap between the stationaries and then continues the gradual slope of increasing voltage as the arc is stretched.

Until now the total back emf has been generated primarily with the voltage associated with the arc column and either 1 or 2 anode and cathode drops. In Section D, it is apparent that the voltage trace slope has changed and the device begins to develop back emf at a faster rate. This occurs when the arc starts to engage the splitter plates as in Figure 9 and more anode and cathode drops are added to the total back emf equation.

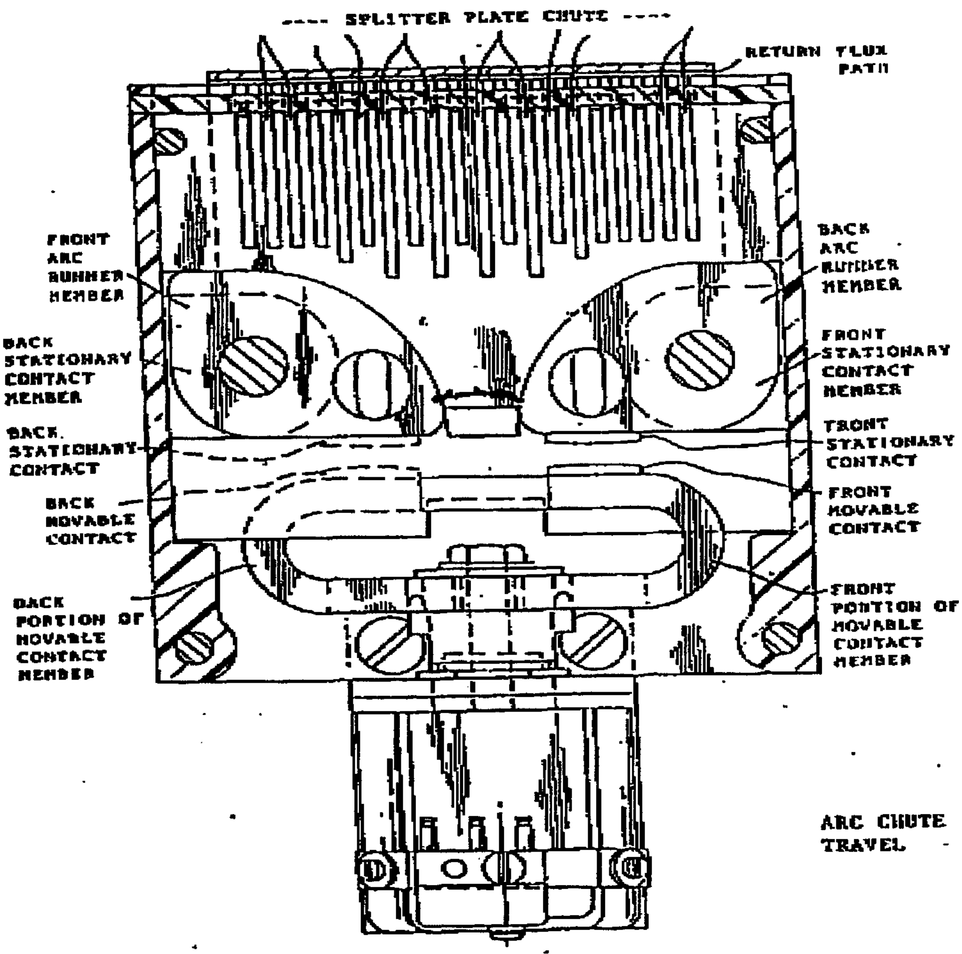


Figure 8. Arc Chute Travel Drawing

In Section E of the voltage trace, the device continues to engage more splitter plates and develop more back emf until the arc has fully engaged the arc chute. At this point the device has developed its maximum back emf and will maintain this voltage until the energy in the reactive elements of the circuit has been dissipated and the current in the circuit approaches zero. In the trace shown, the device developed approximately 350 volts, which exceeds the source of 270 Vdc. At this point the energy in the load had been dissipated and the current was driven to zero. This load was just slightly inductive. In a very inductive load (10 ms time constant or greater) the device would generate as much as 700 volts and maintain this voltage until the current was driven to zero. The voltage trace at this point would be very flat and would drop off sharply to system voltage at the point the current in the circuit was driven to zero.

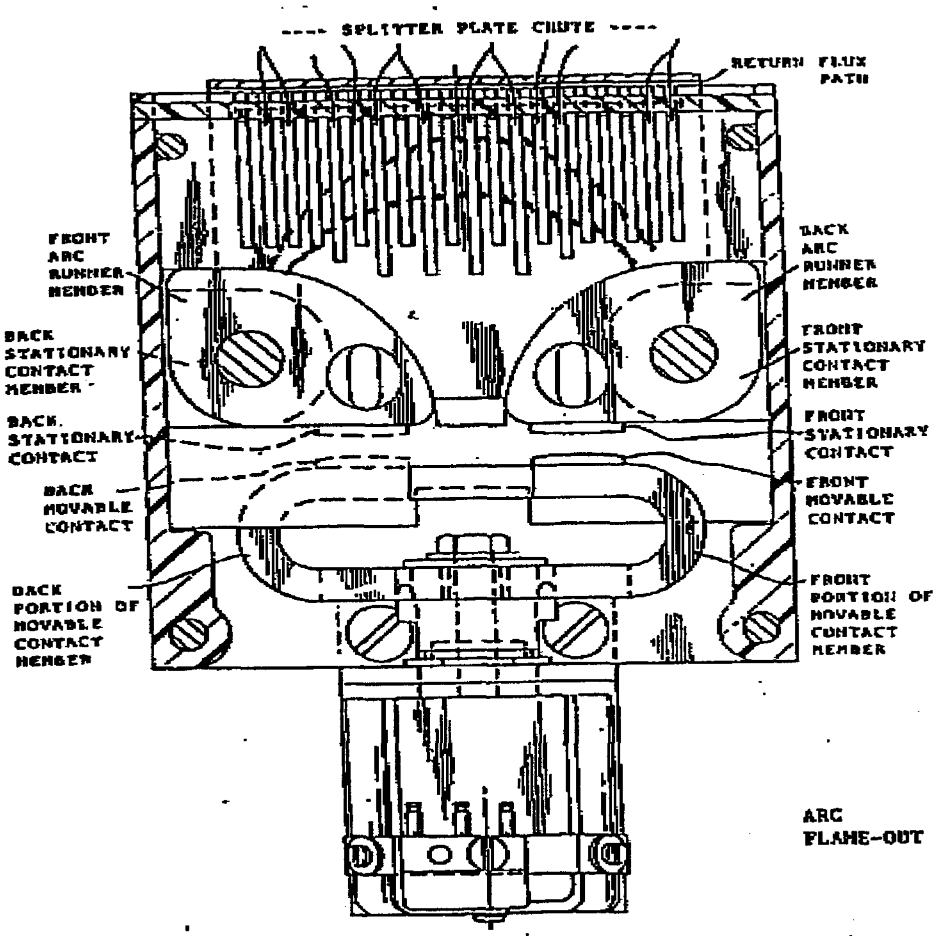


Figure 9. Arc Flame-Out Drawing

3.3 <u>Acceptance Testing</u>

After the design of the contactor was reviewed and approved by Wright Patterson Air Force Research Laboratory, Eaton Corporation had prepared and completed the Acceptance Test (Appendix A) in accordance with the specific requirements from the Contract and Statement of Work. The following sections will summarize the test results and all of the lessons-learned from all the failures that had occurred during the acceptance testing. Appendix B contains the Test Plan and Procedure.

SECTION 4

DISCUSSIONS AND RECOMMENDATIONS, CONCLUSIONS

4.1 Discussions and Recommendations

The HVDC contactor incorporates an arc chute with a permanent magnetic field used to force the arc generated at contact opening into the arc chute. Once the arc engages the arc chute the arc is split between copper plates, which causes the voltage in the arc column to increase. Once this voltage exceeds the source voltage and all energy is dissipated in the circuit, the current will go to zero and circuit interruption is complete.

Two arcs are generated across the double break configuration of the contacts. This is a bi-directional device and the direction of current flow determines which arc will travel into the arc chute and which arc will be shorted and extinguished. The arc to be shorted is called the nuisance arc. During testing of the initial design, it was found that the nuisance arc remained stationary long enough to cause damage to the arc chute material. The idea is to keep this arc moving until it is shorted and extinguished. This physical damage caused by the nuisance arc was preventing us from achieving the electrical life objectives of the program. In order to fix this problem, the movable was redesigned with a turnback allowing the self-field of the current to help push the arc column into the arc chute in a shorter period of time which reduces the time that the nuisance arc can exist. Also the magnetic circuit of the arc chute was changed by which the magnetic field imposed across the arc chute also changed. This change was necessary to help guide the nuisance arc, while it existed, to the area in the arc chute where no physical damage would occur. With these two fixes electrical life objectives were achieved. During the 1000 amp electrical life test where the objective was 5000 operations the device under test completed over 12000 operations. The test was aborted not due to device failure, but because our high voltage power supply failed and required repair.

The dielectric withstands voltage of the HVDC contactor was reduced below the acceptable limits of the acceptance test procedure during the electrical and mechanical life tests. Design changes to prevent dielectric strength reduction are recommended for future product developments. The greatest area of concern is the area between the main terminals. In the current design conductive residue settle on the surface of the arc chute interior from the ionized gasses produced by the arc column. Some ideas to prevent dielectric breakdown in this area include slotting the material between the terminals and/or using a material that would not allow the residue to adhere and build up in this area. The arc chutes used in the prototype units were machined out of plastic. While plastic material is common in this application, the machining process instead of molded parts off a tool is not preferable. During the electrical life at altitude, test one experiment was conducted which does support a material solution for this problem. This is explained in the next paragraph.

The HVDC contactor was designed as a hermetically sealed unit. During the electrical life test at altitude, we were not able to maintain the integrity of the sealed unit. The purpose of sealing the unit was to maintain a higher atmospheric pressure inside the unit when the unit was operating at high altitudes. At higher altitudes, the ability to generate arc voltage in the arc column is reduced because the electrons are not held as tight in the atmosphere at lower atmospheric pressure. However, as we found in our testing, we rely more on the anode and cathode drops between the splits to generate arc voltage than the drop in the arc column itself. While we did have problems maintaining the seal of the unit, we did not have difficulty generating enough arc voltage to interrupt the load at a simulated 60,000 feet during the electrical life test at altitude. It is recommended, based on these test results, that during future product development an assessment be made on the actual need for a sealed unit. An unsealed unit has many advantages over a hermetically sealed unit from a reliability standpoint. One note for future studies in this area has to do with the dielectric issue as stated above. If the dielectric integrity between T1 and T2 is compromised by contamination over the life of the unit, as was the case with our test units, the probability for back commutation at higher altitudes is increased. Back commutation is when the arc almost fully engages the arc chute when a restrike occurs at the entrance to the arc chute because conditions are such (low dielectric strength from T1 to T2) that it takes less voltage to initiate an arc at this point than to maintain the arc voltage through the splitter plates. When this condition occurs, the arc repeats the process continuously and never generates or maintains enough arc voltage to interrupt the load. This was the case during the first test of electrical life at altitude of the prototype test unit. About a third of the way through the test, the dielectric integrity from T1 to T2 was reduced due to contamination and did allow back commutation to occur. In order to prevent this, we coated the inside of the arc chute between T1 and T2 with an epoxy resin, which left a very smooth surface. This smooth surface prevented contamination build up and the unit was able to complete the electrical life test at altitude on the first retest.

The HVDC contactor performed very well and met all objectives during rupture testing. The device was tested in a sequence per the test plan at 350Vdc, 4500 Amps, with a L/R ratio of 3ms. The device successfully completed 20 operations in one direction and 22 operations in the other direction. On the 43d operation of the unit, the device failed to break the load.

The devices performed very well during continuous current testing, considering the size of the unit and the fact that it is a double break configuration. However, problems were experienced during the 1000 amps continuous carry test, especially at 100 °C ambient temperature. While the milli-volt drop across the contacts was acceptable the thermal capacity of the unit was not such that the temperature rise above ambient at the terminals remained below 75 °C. At temperatures above 180 °C at the terminals the materials used in the contactor, at first (machined item), did fail causing extreme damage to the unit. The units were rebuilt using a machined linen phenolic material and while material failure was not a factor, the unit terminal temperature rise was still unacceptable possibly into thermal runaway. This was also a factor, which caused problems maintaining a hermetically sealed unit. Recommendations for future product development include higher contact force in order to reduce the milli-volt drop across the contacts and selection of molded materials for use in the moveable assembly with a temperature rating greater than 220 ° C. Higher contact force has been accomplished with a motor capable of a greater latching force and contact springs capable of a higher load. The motor frame in the current design should also be strengthened with this change.

The device does incorporate a shunt type current sensing device and an electronic trip curve simulation per contract objectives. The device was able to perform within the +/- 7 % tolerance of the nominal I2t trip curves, specified for the 500 and 1000 Amp units.

During testing several failures were observed. Following, is a description of the failures along with design solutions we incorporated in the prototype test unit.

1. In a couple instances, the dc to dc converter was damaged during dielectric testing. The dc to dc converter is the isolation between the shunt device and the electronics, which is good to about 500 volts. This failure occurred due to the contamination inside the unit after many cycles of operation. The electronics were tested from the control power input to the case. If the dielectric withstand between the main terminal (where the shunt is located) and the case was low, it could potentially cause more than 1000 volts to be across the dc to dc converter. This problem is easily solved by increasing the spacing between the main terminals and the case. Also for future development it should be noted that when the design of the current sensor was done the dc to dc converter was the best device available for this application. Currently, isolation amplifiers are available which could replace the dc to dc converter and have more than 1500 volts of isolation.

2 One electronics failure occurred due to contamination build up on the backside of the control connector inside the HVDC contactor. After wires are soldered to this connector, the terminations should be potted to isolate the pins from the contamination.

3. The connector between the shunt and the dc to dc converter incorporates feed through capacitors designed to filter unwanted

noise from the power bus. The capacitors are rated to withstand 300 volts. During dielectric testing from the main terminals to the case, voltages in excess of 1000 volts are placed across the capacitors causing them to blow open. In future developments, a filter scheme (if required) should be designed to withstand the dielectric requirements of the device or the filtering should be done on the other side of the isolation.

4. Connection to the shunt should be via high temperature solder to prevent connection failures due to the high temperature rise of the terminals.

4.2 Conclusions

Utilizing the technologies incorporated into the design of the HVDC contactor and evaluating the test results of the six prototype test devices, it is reasonable to conclude that program objectives have been accomplished both in an engineering unit and in future product developments produced in volume. In addition, it has been shown that it may be feasible to use an unsealed device in applications requiring operation in altitudes of up to 60,000 feet. This would have cost benefits, maintainability benefits, and reliability benefits for future programs.

Appendix A

Acceptance Test Procedure

Eaton Corporation of Florida
Aerospace Controls Division
Manatee Plant
2250 Whitfield Avenue
Sarasota, Fl 34243

Eaton Project No. DV95-6698

ACCEPTANCE TEST PROCEDURE
A50-24885
CONTACTOR WITH CURRENT SENSING
270 Vdc, 500/1000 AMPERES
EATON P/N SM500H1/SM1000H1

Prepared By: Robert E. Shanebrook Date: 4 August 1995
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THE PURPOSE OF THIS SHEET IS TO RECORD THE LATEST REVISION LETTERS OF DOCUMENTS WITH TWO OR MORE SHEETS. SEE APPROPRIATE COLUMNS FOR SHEET NUMBER AND REVISION LETTER OF THAT SHEET.

REVISION BLOCK FOR THIS SHEET ONLY

REV	DESCRIPTION	DATE	DFTG	APPR	REV	DESCRIPTION	DATE	DFTG	APPR
A	Updated with CDR requested data sheet changes, added requirements for sections 5.5, 5.6, 5.7, and 5.8	6/24 1996							
B	Changed "resistance" to "voltage drop" on pages 2, 3, 29, 30, 31, 32, and 47.								

CURRENT REVISION LEVEL OF INDIVIDUAL SHEETS

SHT	REV	SHT	REV	SHT	REV	SHT	REV	SHT	REV	SHT	REV	SHT	REV	SHT	REV	SHT	REV
2	A	14		26	A	38											
3	A	15		27	A	39											
4		16		28		40											
5		17		29	A	41											
6		18	A	30	A	42	A										
7		19	A	31	B	43											
8		20		32	A	44											
9		21	A	33		45											
10		22	A	34		46	A										
11		23		35		47	B										
12		24	A	36		48											
13		25	A	37													

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1.0 INTRODUCTION:

1.1 Scope: This Acceptance Test Procedure (ATP), Eaton Drawing Number A50-24885, has been prepared by Eaton Corporation, Aerospace Controls Division, for the Department of The Air Force, Air Force Material Command, Wright Laboratory, Wright-Patterson AFB, Ohio. This ATP establishes the requirements for prototype acceptance of a SPST, 270 VDC, 500 or 1000 Ampere Contactor being designed under Contract Number F33615-93-C-2359.

1.2 Purpose:

1.2.1 This ATP serves as a framework for planning and conducting the necessary environmental, functional, and electrical tests for verification of Contactor performance.

1.2.2 Verification of the Contactor performance shall be accomplished according to the following plan.

1.2.2.1 All Contactors produced are to be inspected 100% per this ATP prior to shipment or submittal to design verification testing as required by the subject Contract. All testing shall be performed in the order presented.

1.2.2.2 All Contactors must meet the test requirements stated herein unless deviation is granted by the procuring authority.

1.2.2.3 No Contactor will be sealed and/or subjected to the leak test portion of this ATP until after the verification testing is completed and the final test report is approved by the procuring authority.

2.0 APPLICABLE DOCUMENTS:

2.1 Referenced Documents: The following documents of the issue in effect form a part of this document to the extent specified herein. In the event of conflict, this document shall take precedence.

Military

MIL-STD-202	Test Methods for Electronic and Electrical Component Parts
MIL-R-6106J	Relays, Electromagnetic (Including Established Reliability (ER) Types), General Specification for
F33615-93-C-2359	Contract Section C, Description/Specification Dated 30 August 1993, as Amended May 1995

Commercial

SM1000H1& SM500H1 — Suppliers Drawing, SPST Contactor, 270 VDC, 500/1000 Amperes, With Current Sensing

3.0 TABLE OF TESTS: All tests are to be performed in order noted.

ATP A50-24885		REFERENCE	
TEST	DESCRIPTION	SPECIFICATION	METHOD
5.1	Visual and Mechanical	Suppliers Dwg.	Herein
5.2	Insulation Resistance	MIL-STD-202	302
5.3	Dielectric Withstanding Voltage	MIL-STD-202	301
5.4	Operation / Inhibit Test	Suppliers Dwg.	Herein
5.5	Operate and Release Times	Suppliers Dwg.	Herein
5.6	Contact Bounce	Suppliers Dwg.	Herein
5.7	Trip Characteristics	Suppliers Dwg.	Herein
5.8	Contact Resistance	MIL-STD-202	307
5.9	Seal	MIL-STD-202	112E

4.0 LIST OF TEST EQUIPMENT:

NAME	MANUFACTURER	MODEL NO.	RANGE OF SPECTRUM	ALTERNATE EQUIPMENT
Caliper	Mitutoyo	SR44	+/-.001	or Equivalent
Micrometer	Mitutoyo	TBD	+/-.001	or Equivalent
Weight Scale	Pennsylvania	5400	.0001KG<50LB.	or Equivalent
DC Power Supply	Lambda	LLS9040	0-40V @ 20 Amp	or Equivalent
Multimeter	Fluke	8840A	Ohms/Millivolts	or Equivalent
Megohmmeter	General Radio	1864	Ohms	or Equivalent
Hy Pot	Associated Research	OT-472-A DT-472-B	Microamperes	or Equivalent
Oscilloscope Dual Trace Memory	Tektronic	5441	Time	or Equivalent
Electronic Timer	Digitec	8158	TBD	or Equivalent
Contactor Control Box	Special Test Equipment	EATON TNXXXXX	See Appendix A	or Equivalent
Cable Assembly	Special Test Equipment	EATON TNXXXXX	See Appendix A	or Equivalent
Current Load Panel	Special Test Equipment	EATON TNXXXXX	See Appendix A	or Equivalent

5.0 TEST PROCEDURE:

5.1 VISUAL AND MECHANICAL:

5.1.1 Purpose: To confirm that the Contactor meets the dimensional and weight requirements of supplier's drawing and to inspect the Contactor for correctness of marking. In addition, the unit is inspected to insure that workmanship standards are met.

5.1.2 Test Equipment:
- Caliper
- Micrometer
- Weight Scale

5.1.3 Power Requirements:
- None

5.1.4 General Requirements:

5.1.4.1 Verify test equipment is within calibration cycle.

5.1.4.2 Caliper measurements to be used on dimensions greater than one inch. Micrometer measurements to be used for dimensions less than one inch.

5.1.4.3 All dimensions noted, on the applicable suppliers Dimension Drawing, are to be measured and recorded.

5.1.4.4 Any abnormal indications or dimensions out of tolerance constitutes a failure.

5.1.5 Test Procedure:

5.1.5.1 Record date, part number, and serial number of unit being tested on data sheet.

5.1.5.2 Visually inspect Contactor for cracks in ceramics, blisters, burrs, sharp edges, connector damage, and thread damage. Record results or observations on data sheet.

5.1.5.3 Visually inspect nameplate and markings for content as specified on suppliers drawing SM1000H1. Record results or observations on data sheet.

5.1.5.4 Measure all dimensions specified, on the applicable suppliers drawing, using caliper or micrometer. Record results on data sheet.

5.1.5.5 Weigh unit on scale. Insure that unit weight includes all mounting hardware and terminal shield. Record results on data sheet.

5.1.5.6 Visual and Mechanical testing is complete.

5.2 INSULATION RESISTANCE:

5.2.1 Purpose: To measure the resistance offered by the insulating members of a component part to an impressed direct current voltage tending to produce a leakage of current through or on the surface of these members.

5.2.2 Test Equipment:
- Megohmmeter, General Radio 1864 or equivalent
- DC power supply, Lambda LLS9040 or equivalent
- Cable assembly, Eaton P/N TNXXXXXX
- Contactor Control Box, Eaton P/N TNXXXXXX
- Multimeter, Fluke 8840A or equivalent

5.2.3 Power Requirements:
- Insulation Resistance Test - 500 VDC
- Contactor Control - 28 VDC

5.2.4 General Requirements:

5.2.4.1 Test procedure shall be in accordance with MIL-STD-202, Method 302, Test Condition B.

5.2.4.2 Test shall be performed at prevailing factory or laboratory ambient conditions.

5.2.4.3 Test equipment to be turned on for proper warm up time. Approximately thirty minutes.

5.2.4.4 Verify test equipment is within calibration cycle.

5.2.5 Test Procedure: The following procedure shall be executed in sequence. Any reading not meeting the requirements noted on the test data sheet will constitute a failure of the unit under test. Reference Figure 5.2-1 for equipment setup graphic.

5.2.5.1 Connect Contactor Control Box to Contactor and Power Supply as follows.
- Connect connector P1 to Contactor connector J1.
- Connect negative (-) lead of Power Supply to negative (-) POWER IN terminal on Contactor Control Box.
- Connect positive (+) lead of Power Supply to positive (+) POWER IN terminal on Contactor Control Box.

5.2.5.2 Connect Multimeter as follows: (This section verifies Case ground pin prior to applying test potential.)
- Connect positive (+) lead of Multimeter to P1, Pin #7 on Contactor Control Box.
- Connect negative (-) lead of Multimeter to Contactor mounting flange. (Ground)
- Set Multimeter to read OHMS.

- Read Multimeter for short condition. Record measurement on data sheet.
- Disconnect positive (+) lead of Multimeter from P1, Pin #7, and connect to P1, Pin #6 of Contactor Control Box.
- Read Multimeter for an open condition. Record on data sheet.
- Disconnect Multimeter leads from Contactor Control Box.

5.2.5.3 Setup Megohmmeter as follows:

- Set the DISCHARGE/CHARGE/MEASURE switch to DISCHARGE.
- Connect negative (-) lead to the Contactor mounting flange. (Ground)
- Connect positive (+) lead to terminal T1 on the Contactor.
- Set voltage to 500 VDC.
- Set range to 100 Megohms scale.

5.2.5.4 Setup Power Supply and position Contactor contacts to normally open position as follows:

- Set power supply for 28 VDC output.
- Set PWR switch (S1) on Contactor Control Box to CLOSE position.
- Set CONT switch (S2) on Contactor Control Box to OPEN position.
- Set PWR switch (S1) to OPEN position and disconnect P1 of Contactor Control Box from J1 on the Contactor under test.

WARNING - HIGH VOLTAGE BEING APPLIED - WARNING

5.2.5.5 Apply 500 VDC from Megohmmeter by setting the DISCHARGE/CHARGE/MEASURE switch to MEASURE. After two minutes, read resistance on Megohmmeter (M1) and record reading on data sheet. Adjust scale to obtain actual reading. Reading should be greater than 100 megohms. Turn DISCHARGE/CHARGE/MEASURE switch on Megohmmeter to DISCHARGE.

WARNING - HIGH VOLTAGE BEING APPLIED - WARNING

5.2.5.6 Disconnect positive (+) terminal of Megohmmeter from terminal T1 of Contactor and connect to terminal T2 of Contactor. Repeat steps in paragraph 5.2.5.5.

5.2.5.7 Reconnect P1 of Contactor Control Box to J1 of Contactor. Set PWR switch on Contactor Control Box to CLOSE position and set CONT switch (S2) to CLOSE position.

WARNING - HIGH VOLTAGE BEING APPLIED - WARNING

5.2.5.8 Set PWR switch (S1) to OPEN position and disconnect P1 of Contactor Control Box from J1 on the Contactor under test. Repeat steps in paragraph 5.2.5.5.

5.2.5.9 Reconnect P1 of Contactor Control Box to J1 of Contactor. Set PWR switch on Contactor Control Box to CLOSE position and set CONT switch (S2) to OPEN position.

WARNING - HIGH VOLTAGE BEING APPLIED - WARNING

5.2.5.10 Reconnect Megohmmeter by disconnecting the negative (-) lead from the contactor case ground and connect the lead to the T1 terminal on the Contactor. Repeat steps 5.2.5.8.

5.2.5.11 Connect P1 of Cable Assembly, Eaton P/N TNXXXXXX, to connector J1 of Contactor.

WARNING - HIGH VOLTAGE BEING APPLIED - WARNING

5.2.5.12 Reconnect Megohmmeter as follows:

- Disconnect the positive (+) lead from terminal T2 on the Contactor and connect to P2 of Cable Assembly.
- Disconnect the negative (-) lead from terminal T1 on the Contactor and connect to Contactor mounting flange. (Ground) Repeat steps 5.2.5.5.

5.2.5.13 Reset all switches on Contactor Control Box to the OPEN position.

5.2.5.14 Disconnect all test equipment. Insulation Resistance tests are complete.

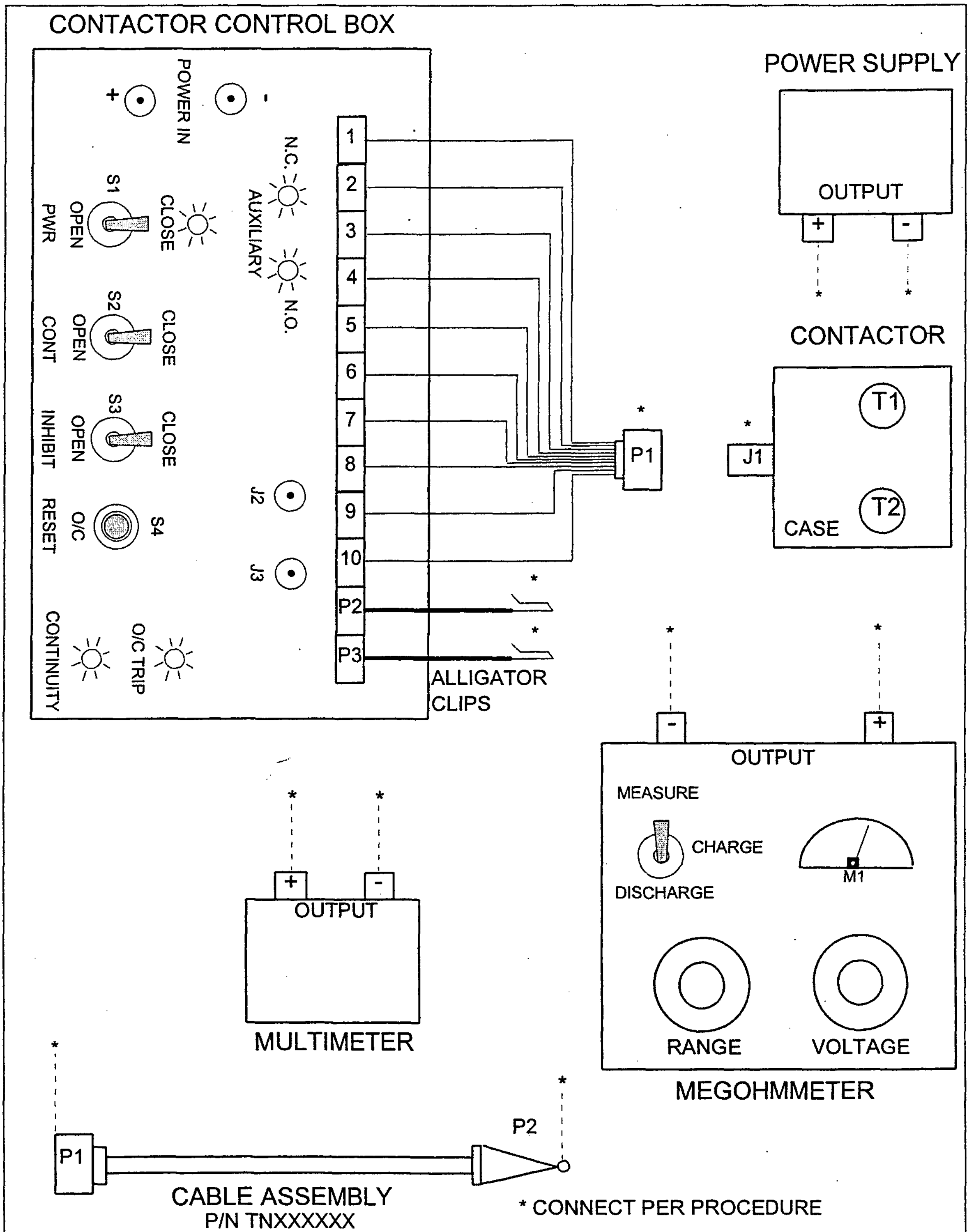


FIGURE 5.2-1

Insulation Resistance, Test Setup

5.3 DIELECTRIC WITHSTANDING VOLTAGE:

5.3.1 Purpose: The Dielectric Withstanding Voltage test is used to establish that the component part can operate safely at its rated voltage and withstand momentary over potentials due to switching surges and other similar phenomena.

5.3.2 Test Equipment:
- Hy Pot Tester DT-472-A/DT-472-B
- DC power supply, Lambda LLS9040 or equivalent
- Cable assembly, Eaton P/N TNXXXXXX
- Contactor Control Box, Eaton P/N TNXXXXXX

5.3.3 Power Requirements:
- Main Contacts - 1500 Vrms @ 60 Hz
- Electronics - 1050 Vrms @ 60 Hz
- 28 VDC

5.3.4 General Requirements:

5.3.4.1 This test procedure shall be performed in accordance with MIL-STD-202, Method 301.

5.3.4.2 Test shall be performed at prevailing factory or laboratory ambient conditions.

5.3.4.3 Test equipment to be turned on for proper warm up time. Approximately thirty minutes.

5.3.4.4 Verify test equipment is within calibration cycle.

5.3.4.5 Maximum leakage permitted is 1.0 Milliamperes.

5.3.5 Test Procedure: The following procedure shall be executed in sequence. Any failure, whether visual or read, constitutes failure of the unit under test. Reference Figure 5.3-1 for equipment setup graphic.

5.3.5.1 Connect Contactor Control Box to Contactor and Power Supply as follows.
- Connect connector P1 to Contactor connector J1.
- Connect negative (-) lead of Power Supply to negative (-) POWER IN terminal on Contactor Control Box.
- Connect positive (+) lead of Power Supply to positive (+) POWER IN terminal on Contactor Control Box.

5.3.5.2 Setup Hy Pot Tester as follows:
- Press the POWER switch to the ON position.
- Press the TEST push-button.

•Adjust MIN. knob to a reading of 1.5 VAC on KILOVOLTS indicator.
•Set RAMP TIME to three (3) seconds.
•Set DWELL TIME to sixty (60) seconds.

5.3.5.4 Setup Power Supply and position Contactor contacts to normally open position as follows:

•Set power supply for 28 VDC output.
•Set PWR switch (S1) on Contactor Control Box to CLOSE position.
•Set CONT switch (S2) on Contactor Control Box to OPEN position.
•Set PWR switch (S1) to OPEN position and disconnect P1 of Contactor Control Box from J1 on the Contactor under test.

5.3.5.5 Connect the black terminal lead of Hy Pot tester to Contactor mounting flange. (Ground) Connect the red lead of Hy Pot tester to terminal T1 on Contactor.

WARNING - HIGH VOLTAGE BEING APPLIED - WARNING

5.3.5.6 Press the TEST push-button to apply 1500 VAC to the unit under test. Hy Pot tester will time out and turn off automatically after the one minute time period.

•Monitor the Contactor for any arc-over (air discharge), flash-over (surface discharge), and breakdown (puncture discharge). Observe the buzzer on the Hy Pot tester for continuous sound.
•Record results on data sheet.

WARNING - HIGH VOLTAGE BEING APPLIED - WARNING

5.3.5.7 Reconnect Hy Pot tester by removing the red terminal of the Hy Pot tester from terminal T1 on Contactor and connect to terminal T2. Repeat step 5.3.5.6.

5.3.5.8 Reconnect P1 of Contactor Control Box to J1 on the Contactor.

•Set PWR switch (S1) on Contactor Control Box to CLOSE position.
•Set CONT switch (S2) on Contactor Control Box to CLOSE position.
•Set PWR switch (S1) to OPEN position and disconnect P1 of Contactor Control Box from J1 on the Contactor under test.

WARNING - HIGH VOLTAGE BEING APPLIED - WARNING

5.3.5.9 Repeat step 5.3.5.6.

5.3.5.10 Reconnect P1 of Contactor Control Box to J1 on the Contactor.

•Set PWR switch (S1) on Contactor Control Box to CLOSE position.
•Set CONT switch (S2) on Contactor Control Box to OPEN position.
•Set PWR switch (S1) to OPEN position and disconnect P1 of Contactor Control Box from J1 on the Contactor under test.

WARNING - HIGH VOLTAGE BEING APPLIED - WARNING

5.3.5.11 Reconnect Hy Pot tester by removing the black terminal lead from the Contactor case ground and connect the black lead to Contactor terminal T1. Repeat step 5.3.5.6.

5.3.5.12 Disconnect the red terminal lead of the Hy Pot tester from terminal T2 of Contactor and the black lead of the Hy Pot tester from terminal T1 of Contactor.

5.3.5.13 Setup Hy Pot tester as follows:

- Press the TEST push-button.
- Rotate MIN. control to readjust voltage on Hy Pot tester to 1.05 KVAC.
- Readjust the RAMP TIME on Hy Pot tester to two (2) seconds.
- Connect the black terminal lead from Hy Pot tester to the Contactor mounting flange. (Ground).
- Connect the red terminal lead from the Hy Pot tester to P2 of Cable Assembly, Eaton P/N TNXXXXXX.
- Connect P1 of Cable Assembly to J1 of Contactor.

WARNING - HIGH VOLTAGE BEING APPLIED - WARNING

5.3.5.14 Press the TEST push-button to apply 1050 VAC to the unit under test. Hy Pot tester will time out and turn off automatically after the two minute time period.

- Monitor the Contactor for any arc-over (air discharge), flash-over (surface discharge), and breakdown (puncture discharge). Observe the buzzer on the Hy Pot tester for continuous sound.
- Record results on data sheet.

5.3.5.15 Reset all switches on Contactor Control Box to the OPEN position.

5.3.5.16 Disconnect all test equipment. Dielectric Withstanding Voltage tests are complete.

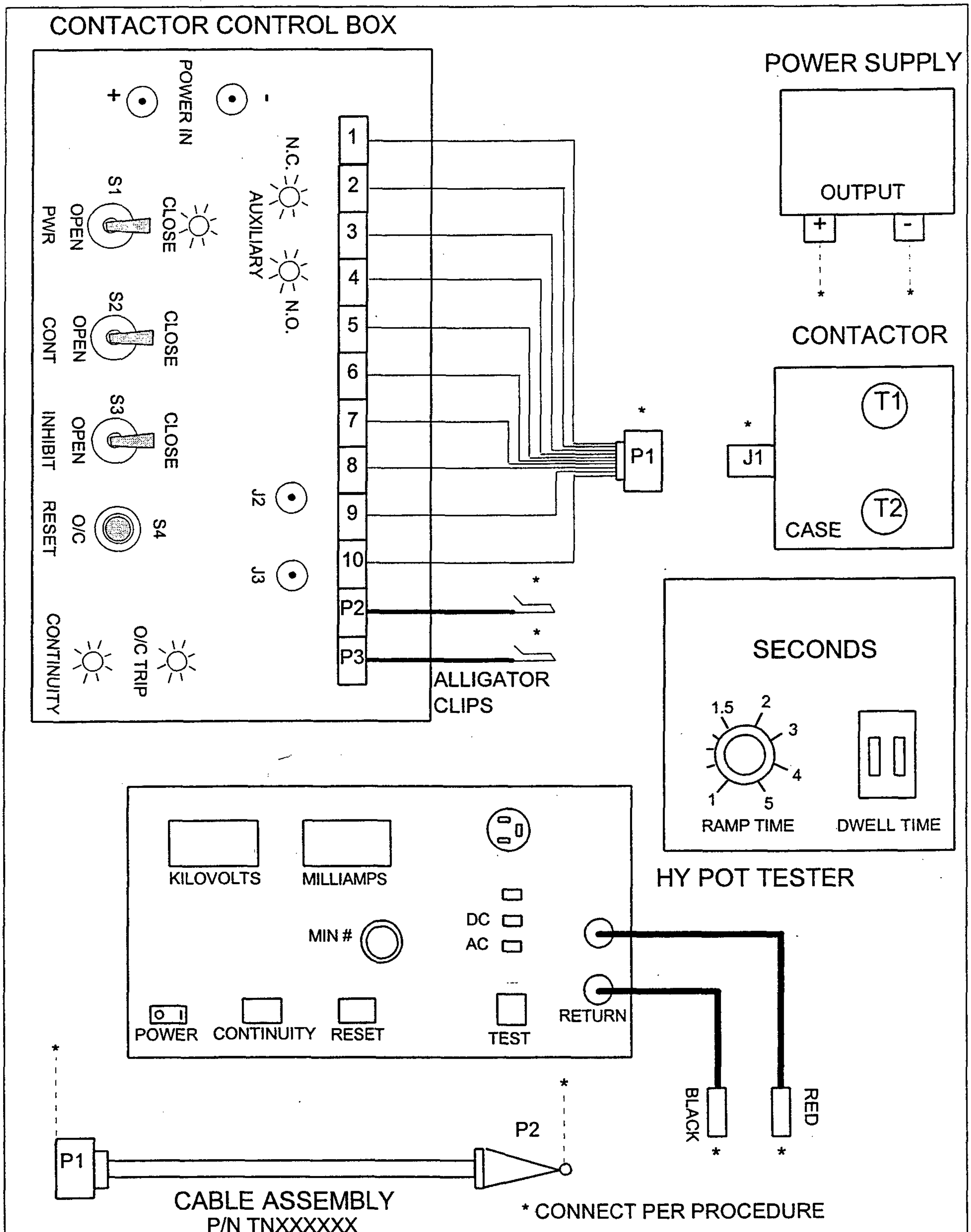


FIGURE 5.3-1

Dielectric Withstanding Voltage, Test Setup

5.4 OPERATION / INHIBIT TEST:

5.4.1 Purpose: To verify the electronic Inhibit / Control logic of the Contactor as represented in the logic diagram pictured on the applicable Eaton drawing. In addition, this test sequence verifies the minimum operating voltage of the electronics and Contactor auxiliary operation.

5.4.2 Test Equipment:
- Contactor Control Box, Eaton P/N TNXXXXXX
- DC Power Supply, Lambda LLS9040 or equivalent

5.4.3 Power Requirements:
- 15.5 VDC to 18 VDC

5.4.4 General Requirements:

5.4.4.1 Test shall be performed at prevailing factory or laboratory ambient conditions.

5.4.4.2 Test equipment to be turned on for proper warm up time. Approximately thirty minutes.

5.4.4.3 Verify test equipment is within calibration cycle.

5.4.5 Test Procedure: The following procedure shall be executed in sequence. Any observation not meeting the requirements shall constitute a failure and will be cause for rejection of the Contactor under test. Reference Figure 5.4-1 for equipment setup graphic.

5.4.5.1 Setup Contactor Control Box and Power Supply as follows:
- Connect P1 of Contactor Control Box to J1 on Contactor.
- Connect negative (-) lead of Power Supply to negative (-) POWER IN terminal on Contactor Control Box.
- Connect positive (+) lead of Power Supply to positive (+) POWER IN terminal on Contactor Control Box.
- Connect P2 of Contactor Control Box to terminal T1 on Contactor.
- Connect P3 of Contactor Control Box to terminal T2 on Contactor.

5.4.5.2 Insure that all switches on the Contactor Control Box are set in the OPEN position.

5.4.5.3 Turn-on Power Supply and set voltage to 18 VDC.

5.4.5.4 Set PWR switch (S1) on Contactor Control Box to CLOSE. CONTINUITY light and auxiliary NC light on Contactor Control Box should **not** be illuminated, and, the auxiliary NO light should be illuminated. Record indications on Data Sheet.

5.4.5.5 Set CONT switch (S2) on Contactor Control Box to CLOSE. CONTINUITY light and auxiliary NC light on Contactor Control Box should be illuminated, and, the auxiliary NO light should **not** be illuminated. Record indications on Data Sheet.

5.4.5.6 Set INHIBIT switch (S3) on Contactor Control Box to CLOSE. CONTINUITY light and auxiliary NC light on Contactor Control Box should **not** be illuminated, and, the auxiliary NO light should be illuminated. Record indications on Data Sheet.

5.4.5.7 Set CONT switch (S2) to OPEN. CONTINUITY light and auxiliary NC light on Contactor Control Box should **not** be illuminated, and, the auxiliary NO light should be illuminated. Record indications on Data Sheet.

5.4.5.8 Set PWR switch (S1) to OPEN position. Set CONT switch (S2) to CLOSE. Set INHIBIT switch (S3) to OPEN. Reset PWR switch to CLOSE position. CONTINUITY light and auxiliary NC light on Contactor Control Box should be illuminated, and, the auxiliary NO light should **not** be illuminated. Record indications on Data Sheet.

5.4.5.9 Set PWR switch (S1) to OPEN position. Set CONT switch (S2) to OPEN. Reset PWR switch to CLOSE position. CONTINUITY light and auxiliary NC light on Contactor Control Box should **not** be illuminated, and, the auxiliary NO light should be illuminated. Record indications on Data Sheet.

5.4.5.10 Set PWR switch (S1) to OPEN position. Set CONT switch (S2) to CLOSE. Reset PWR switch to CLOSE position. CONTINUITY light and auxiliary NC light on Contactor Control Box should be illuminated, and, the auxiliary NO light should **not** be illuminated. Record indications on Data Sheet.

5.4.5.11 Set all switches to their OPEN positions.

5.4.5.12 Set Power Supply voltage to 15.9 VDC. Set PWR switch (S1) to CLOSE position. Set CONT switch (S2) to CLOSE position. CONTINUITY light and auxiliary NC light on Contactor Control Box should **not** be illuminated, and, the auxiliary NO light should be illuminated. Record indications on Data Sheet.

5.4.5.13 Set all switches to their OPEN positions.

5.4.5.14 Set Power Supply voltage to 16.1 VDC. Set PWR switch (S1) to CLOSE position. Set CONT switch (S2) to CLOSE position. CONTINUITY light and auxiliary NC light on Contactor Control Box should be illuminated, and, the auxiliary NO light should **not** be illuminated. Record indications on Data Sheet.

5.4.5.15 Set all switches on Contactor Control Box to their OPEN positions.

5.4.5.16 Disconnect all test equipment. Test is complete.

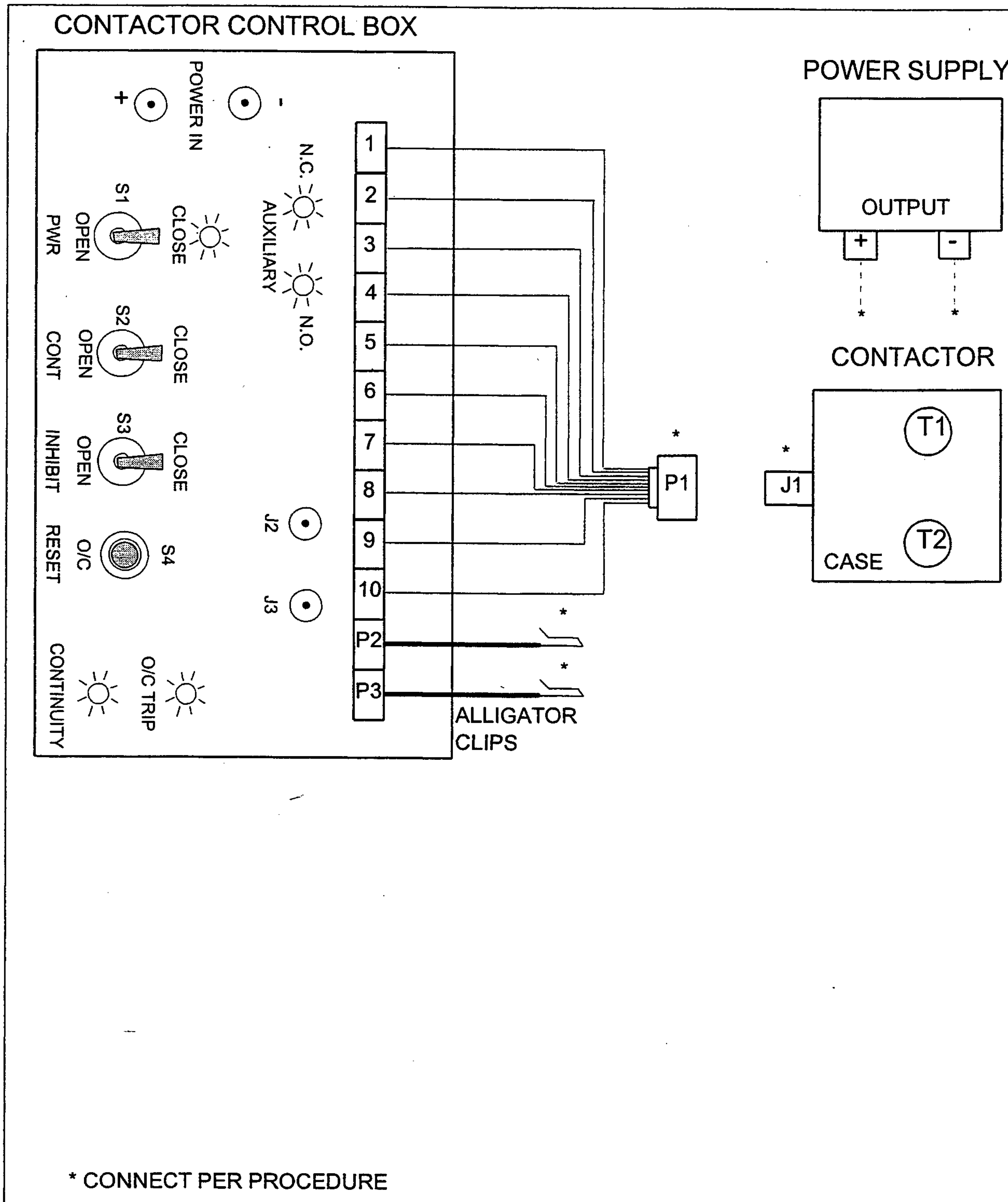


FIGURE 5.4-1

Operation / Inhibit, Test Setup

5.5 OPERATE AND RELEASE TIMES:

5.5.1 Purpose: To measure and record the time from the application of control voltage to the time of actual opening and closing of the Contactor's main contacts.

5.5.2 Test Equipment:
- Contactor Control Box, Eaton P/N TNXXXXXX
- DC Power Supply, Lambda LLS9040 or equivalent
- Oscilloscope, Tektronix 5441 or equivalent

5.5.3 Power Requirements:
- 18 VDC

5.5.4 General Requirements:

5.5.4.1 Test shall be performed at prevailing factory or laboratory ambient conditions.

5.5.4.2 Test equipment to be turned on for proper warm up time. Approximately thirty minutes.

5.5.4.3 Verify test equipment is within calibration cycle.

5.5.4.4 Maximum Operating Time = TBD milliseconds.

5.5.4.5 Maximum Release Time = TBD milliseconds.

5.5.5 Test Procedure: The following procedure shall be executed in sequence. Any reading not meeting the requirements shall constitute a failure and will be cause for rejection of the Contactor under test. Reference Figure 5.5-1 for equipment setup graphic.

5.5.5.1 Setup Contactor Control Box and Power Supply as follows:
- Connect P1 of Contactor Control Box to J1 on Contactor.
- Connect negative (-) lead of Power Supply to negative (-) POWER IN terminal on Contactor Control Box.
- Connect positive (+) lead of Power Supply to positive (+) POWER IN terminal on Contactor Control Box.
- Connect P2 of Contactor Control Box to terminal T1 on Contactor.
- Connect P3 of Contactor Control Box to terminal T2 on Contactor.

5.5.5.2 Turn-on Power Supply and set voltage to 18 VDC.

5.5.5.3 Set PWR switch (S1) on Contactor Control Box to CLOSE.

5.5.5.4 Set CONT switch (S2) on Contactor Control Box to OPEN. CONTINUITY indicator light on Contactor Control Box should NOT be illuminated. Record observation on Data Sheet.

5.5.5.5 Setup oscilloscope as follows:

- Connect coaxial cable from J2 on Contactor Control Box to Channel A input of Oscilloscope.
- Connect coaxial cable from J3 on Contactor Control Box to Channel B input of Oscilloscope.
- On Oscilloscope set controls for memory, time interval, Channel A trig at 50% level negative (-) slope, and Channel B trig at 50% level positive (+) slope.

5.5.5.6 Set CONT switch (S2) on Contactor Control Box to CLOSE position. Read Oscilloscope for time interval of less than TBD milliseconds and record Operate time on Data Sheet.

5.5.5.7 Set Oscilloscope controls to memory, time internal, Channel A trig at 50% level positive (+) slope, and Channel B trig at negative (-) slope.

5.5.5.8 Set CONT switch (S2) on Contactor Control Box to OPEN position. Read Oscilloscope for time interval of less than TBD milliseconds and record Release time on Data Sheet.

5.5.5.9 Reset all switches on Contactor Control Box to the OPEN position.

5.5.5.10 Disconnect all test equipment, Operate/Release time test is complete.

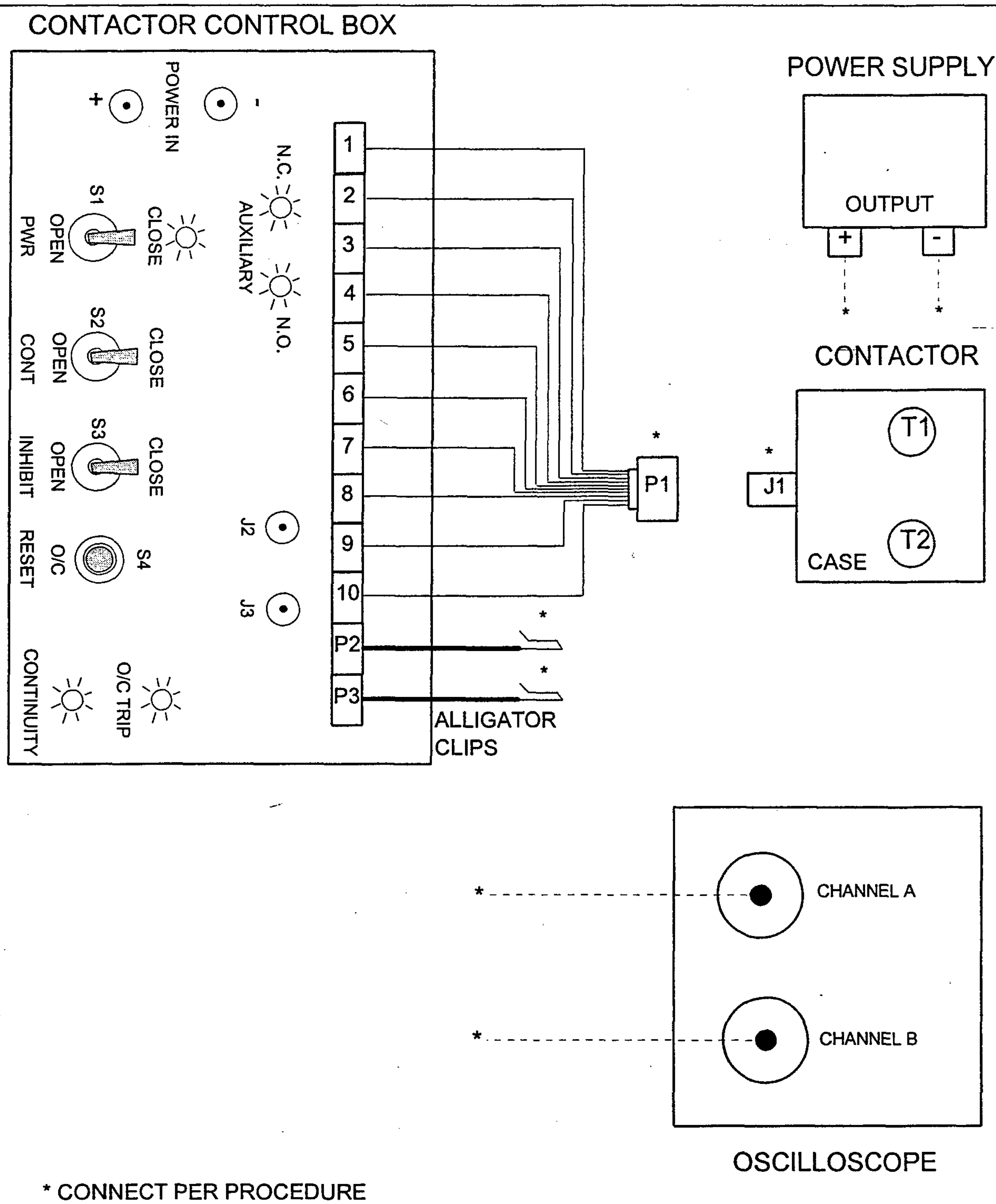


FIGURE 5.5-1

Operate and Release Times, Test Setup

5.6 CONTACT BOUNCE:

5.6.1 Purpose: To check contact bounce characteristics of the Contactor by measuring the settling time of the relay contacts.

5.6.2 Test Equipment:
- Contactor Control Box, Eaton P/N TNXXXXXX
- DC Power Supply, Lambda LLS9040 or equivalent.
- Oscilloscope, Tektronix 5441 or equivalent.

5.6.3 Power Requirements:
- 28 VDC

5.6.4 General Requirements:

5.6.4.1 Test shall be performed at prevailing factory or laboratory ambient conditions.

5.6.4.2 Test equipment to be turned on for proper warm up time. Approximately thirty minutes.

5.6.4.3 Verify test equipment is within calibration cycle.

5.6.4.4 Maximum Contact Bounce Permitted = TBD milliseconds. This requirement is based upon the average of five (5) readings.

5.6.5 Test Procedure: The following procedure shall be executed in sequence. Any average reading not meeting the requirements shall constitute a failure and will be cause for rejection of the Contactor under test. Reference Figure 5.6-1 for equipment setup graphic.

5.6.5.1 Setup Contactor Control Box and Power Supply as follows:
- Connect P1 of Contactor Control Box to J1 on Contactor.
- Connect negative (-) lead of Power Supply to negative (-) POWER IN terminal on Contactor Control Box.
- Connect positive (+) lead of Power Supply to positive (+) POWER IN terminal on Contactor Control Box.
- Connect P2 of Contactor Control Box to terminal T1 on Contactor.
- Connect P3 of Contactor Control Box to terminal T2 on Contactor.

5.6.5.2 Turn-on Power Supply and set voltage to 28 VDC.

5.6.5.3 Set PWR switch (S1) on Contactor Control Box to CLOSE.

5.6.5.4 Set CONT switch (S2) on Contactor Control Box to OPEN. CONTINUITY indicator light on Contactor Control Box should NOT be illuminated. Record observation on Data Sheet.

5.6.5.5 Setup oscilloscope as follows:

- Connect coaxial cable from J3 on Contactor Control Box to Channel A input of Oscilloscope.
- On Oscilloscope set controls for memory, time interval, Channel A start, trig at 10% level positive (+) slope, Channel A stop, trig at 90% level positive (+) slope, and time per division = msec.

5.6.5.6 Set CONT switch (S2) on Contactor Control Box to CLOSE position. Read Oscilloscope for time interval of less than TBD milliseconds and record Bounce time #1 on Data Sheet.

5.6.5.7 Repeat steps 5.6.5.4 through 5.6.5.6 four (4) additional times. Average all five (5) readings for pass / fail determination.

5.6.5.8 Reset all switches on Contactor Control Box to the OPEN position.

5.6.5.9 Disconnect all test equipment, contact bounce test is complete.

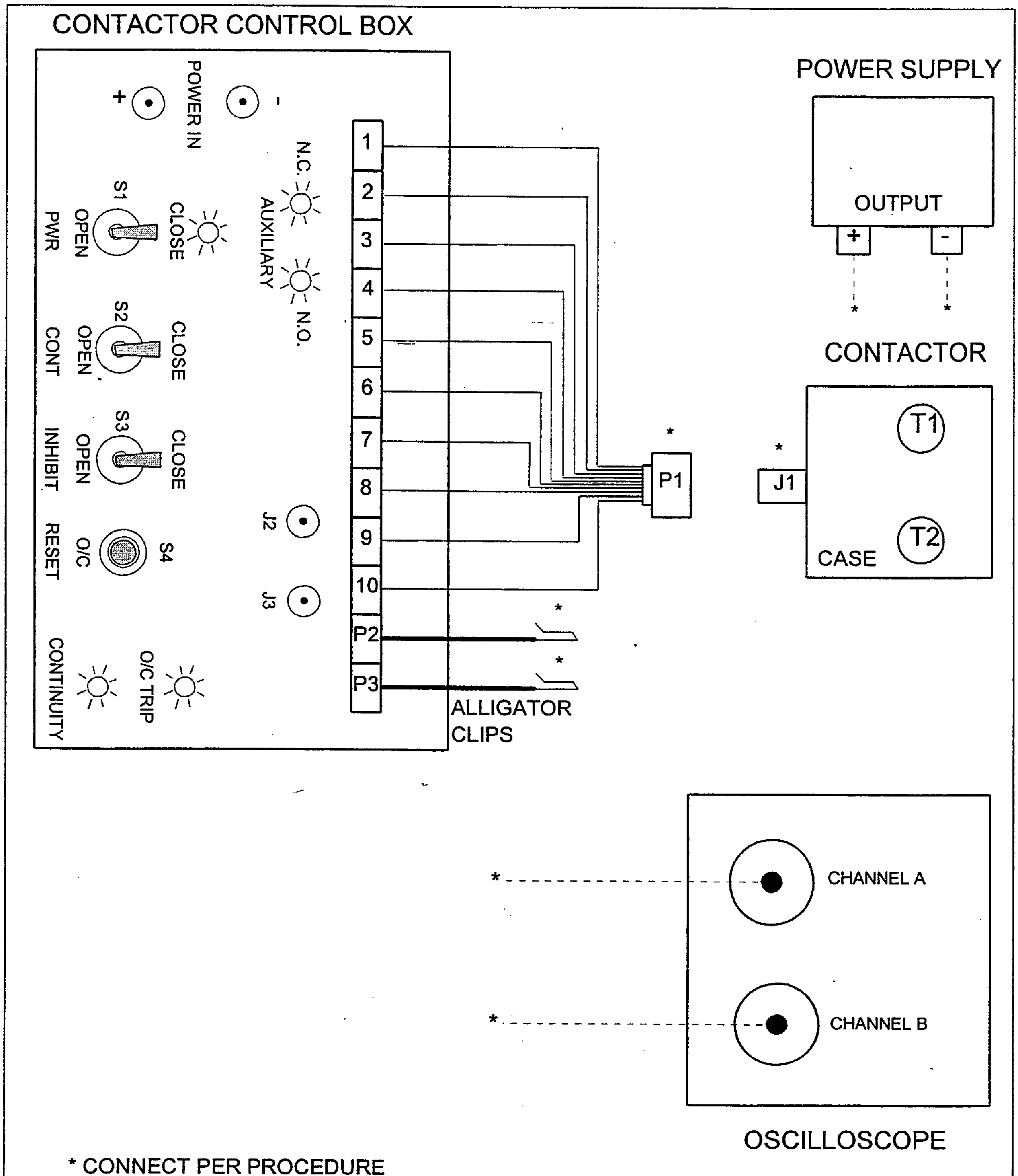


FIGURE 5.6-1

Contact Bounce Times, Test Setup

5.7 TRIP CHARACTERISTICS:

5.7.1 Purpose: To verify the over current trip curve of the Contactor by measuring trip times at selected current levels on the trip curve. For proper verification, measurements are made with current flowing through the Contactor in each direction. (Positive on Contactor terminal T1 and Positive on Contactor terminal T2) This test is only performed on units built with current sensing capabilities.

5.7.2 Test Equipment:
- Contactor Control Box, Eaton P/N TNXXXXXX
- DC Power Supply, Lambda LLS9040 or equivalent
- Current Load Panel, Eaton P/N TNXXXXXX
- DUMMY Load Panel, Eaton P/N TNXXXXXX
- Electronic Timer, Digitec 8158 or equivalent

5.7.3 Power Requirements:
- 28 VDC
- 28 VDC, 400 to 4500 Amperes

5.7.4 General Requirements:

5.7.4.1 Test shall be performed at prevailing factory or laboratory ambient conditions.

5.7.4.2 Test equipment to be turned on for proper warm up time. Approximately thirty minutes.

5.7.4.3 Verify test equipment is within calibration cycle.

5.7.5 Test Procedure: The following procedure shall be executed in sequence. Any observation not meeting the requirements shall constitute a failure and will be cause for rejection of the Contactor under test. Reference Figure 5.7-1 for equipment setup graphic.

5.7.5.1 Setup Contactor Control Box and Power Supply as follows:
- Connect P1 of Contactor Control Box to J1 on Contactor.
- Connect negative (-) lead of Power Supply to negative (-) POWER IN terminal on Contactor Control Box.
- Connect positive (+) lead of Power Supply to positive (+) POWER IN terminal on Contactor Control Box.

5.7.5.2 Turn-on Power Supply and set voltage to 28 VDC.

5.7.5.3 Insure PWR and CONT switches on Contactor Control Box are set to the OPEN position.

5.7.5.4 Connect Current Load Panel to Contactor as follows:

- Connect negative (-) lead from DUMMY / TEST Load Panel to terminal T2 on unit under test.
- Connect positive (+) lead from DUMMY / TEST Load Panel to terminal T1 on unit under test.

WARNING - HIGH CURRENT POTENTIAL - WARNING

5.7.5.5 Set Constant Current level using Dummy Load as follows: (Ref. Table 5.7-A)
- Connect negative (-) lead of Current Load Panel to terminal T2 on DUMMY / TEST Load Panel.
- Connect positive (+) lead of Current Load Panel to terminal T1 on DUMMY / TEST Load Panel.
- Set DUMMY / Test switch to DUMMY.
- Turn-on Current Load Panel.
- Adjust Constant Current per Table 5.7-A.

5.7.5.6 Set PWR switch (S1) to CLOSED position. Then set CONT switch (S2) to CLOSED position.

5.7.5.7 Apply Constant Current load to unit under test by setting the DUMMY / TEST switch to the TEST position.

5.7.5.8 Observe O/C TRIP indicator on Contactor Control Box is extinguished and CONTACT TIMER on Current Load Panel is operating.

5.7.5.9 After thirty (30) minutes, observe that O/C TRIP indicator is still extinguished and that the CONTACT TIMER is still counting. Record observations on Data Sheet.

5.7.5.10 Set DUMMY / TEST switch to DUMMY. Disconnect power at Current Load Panel.

5.7.5.11 Reconnect Load to Contactor as follows to verify operation with reverse current flow.
- Connect negative (-) lead from DUMMY / TEST Load Panel to terminal T1 on unit under test.
- Connect positive (+) lead from DUMMY / TEST Load Panel to terminal T2 on unit under test.

WARNING - HIGH CURRENT POTENTIAL - WARNING

5.7.5.12 Connect power at Current Load Panel.

5.7.5.13 Repeat steps 5.7.5.7 through 5.7.5.10.

5.7.5.14 Insure DUMMY / TEST switch is set to DUMMY. Turn-on Current Load Panel and adjust current for Trip Current #1 per Table 5.7-A.

5.7.5.15 Apply Trip Current #1 load to unit under test by setting the DUMMY / TEST switch to the TEST position.

5.7.5.16 Observe O/C TRIP indicator on Contactor Control Box is illuminated and CONTACT TIMER on Current Load Panel is stopped. Record reading from CONTACT TIMER and indication of O/C TRIP indicator (ON) on Data Sheet. Reading should be per Table 5.7-A.

5.7.5.17 Switch TEST/DUMMY switch to DUMMY position. Disconnect power at Current Load Panel.

5.7.5.18 Press O/C RESET switch (S4) on Contactor Control Box. Observe that O/C TRIP indicator is extinquished. Record indication on Data Sheet.

5.7.5.19 Reverse polarity at terminals of unit under test and connect power at Current Load Panel.

WARNING - HIGH CURRENT POTENTIAL - WARNING

5.7.5.20 Repeat steps 5.7.5.15 through 5.7.5.18.

5.7.5.21 Setup and test for Trip Current #2 per steps 5.7.5.14 through 5.7.5.20 except use Trip Current #2 current level from Table 5.7-A.

5.7.5.22 Setup and test for Trip Current #3 per steps 5.7.5.14 through 5.7.5.20 except use Trip Current #3 current level from Table 5.7-A.

5.7.5.23 Setup and test for Trip Current #4 per steps 5.7.5.14 through 5.7.5.20 except use Trip Current #4 current level from Table 5.7-A.

5.7.5.24 Setup and test for Trip Current #5 per steps 5.7.5.14 through 5.7.5.20 except use Trip Current #5 current level from Table 5.7-A

5.7.5.25 Turn-off all power and disconnect all equipment. Trip Characteristics test is complete.

ATP TRIP CURRENT / TIMES				
--- Test	SM500H1		SM1000H1	
	Current Level Amp.	Trip Time	Current Level Amp.	Trip Time
Constant Current	500	NO TRIP	1000	NO TRIP
Trip Current #1	TBD	TBD	TBD	TBD
Trip Current #2	TBD	TBD	TBD	TBD
Trip Current #3	TBD	TBD	TBD	TBD
Trip Current #4	TBD	TBD	TBD	TBD
Trip Current #5	TBD	TBD	TBD	TBD

TABLE 5.7-A

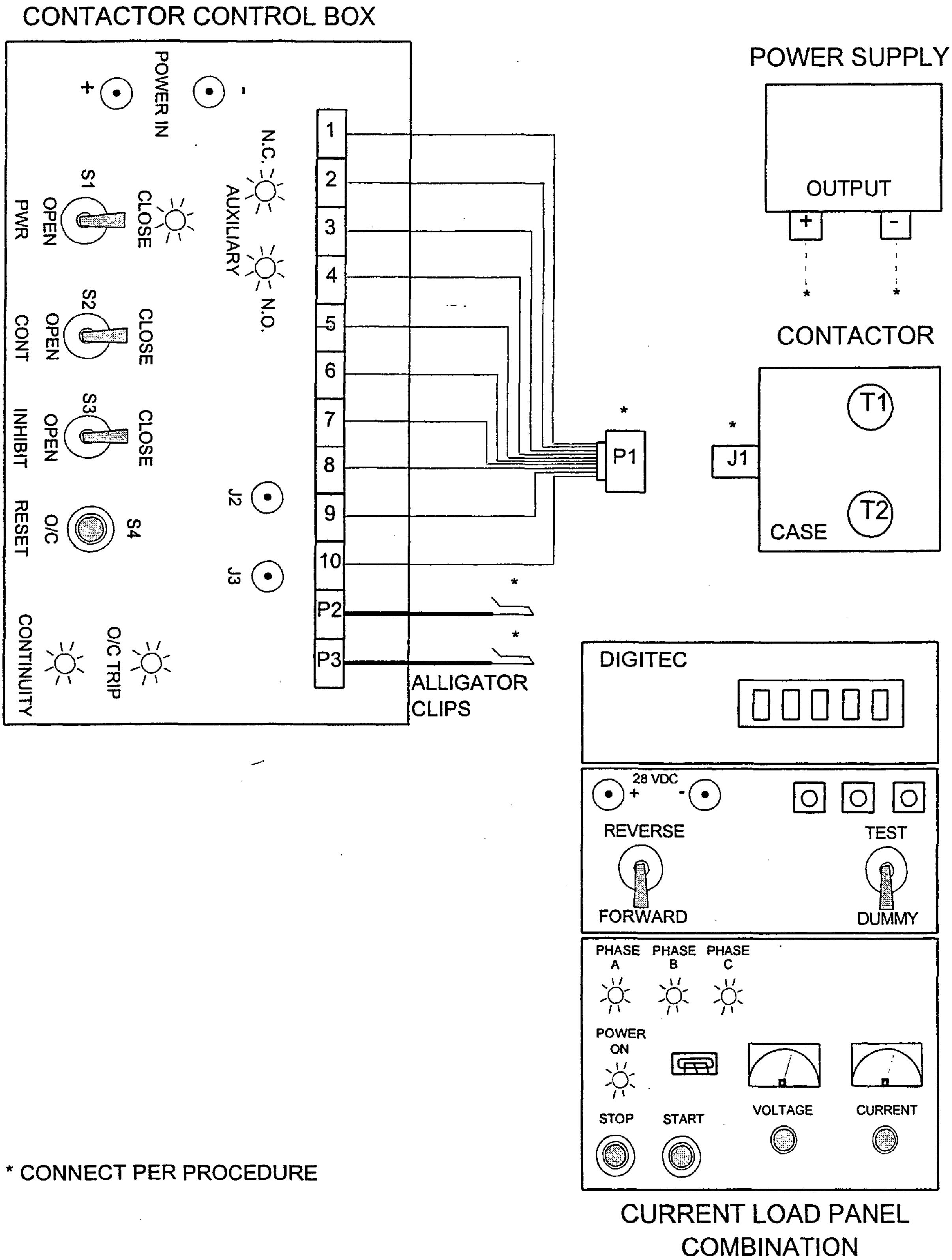


FIGURE 5.7-1

Trip Characteristics, Test Setup

5.8 CONTACT VOLTAGE DROP TEST:

5.8.1 Purpose: To determine the electrical voltage drop between conducting surfaces and terminals of the device under test while carrying continuous duty rated current.

5.8.2 Test Equipment:

- Contactor Control Box, Eaton P/N TNXXXXXX
- DC Power Supply, Lambda LLS9040 or equivalent
- Current Load Panel, Eaton P/N TNXXXXXX
- DUMMY Load Panel, Eaton P/N TNXXXXXX
- Electronic Timer, Digitec 8158 or equivalent
- Multimeter, Fluke 8840A or equivalent

5.8.3 Power Requirements:

- 28 VDC
- 0 to 18 VDC, 500 to 1000 Amperes

5.8.4 General Requirements:

5.8.4.1 Test shall be performed at prevailing factory or laboratory ambient conditions.

5.8.4.2 Test equipment to be turned on for proper warm up time. Approximately thirty minutes.

5.8.4.3 Verify test equipment is within calibration cycle.

5.8.4.4 The maximum Contact Voltage Drop permitted is listed in Table 5.8-A. This requirement is based upon the average of five (5) readings.

5.8.4.5 Test procedure shall be in accordance with MIL-STD-202, Method 307, except as noted herein.

5.8.5 Test Procedure: The following procedure shall be executed in sequence. Any average reading not meeting the requirements shall constitute a failure and will be cause for rejection of the Contactor under test. Reference Figure 5.8-1 for equipment setup graphic.

5.8.5.1 Setup Contactor Control Box and Power Supply as follows:

- Connect P1 of Contactor Control Box to J1 on Contactor.
- Connect negative (-) lead of Power Supply to negative (-) POWER IN terminal on Contactor Control Box.
- Connect positive (+) lead of Power Supply to positive (+) POWER IN terminal on Contactor Control Box.

5.8.5.2 Turn-on Power Supply and set voltage to 18 VDC.

5.8.5.3 Insure PWR and CONT switches on Contactor Control Box are set to the OPEN position.

5.8.5.4 Connect Current Load Panel to Contactor as follows:
- •Connect negative (-) lead from DUMMY / TEST Load Panel to terminal T2 on unit under test.
- •Connect positive (+) lead from DUMMY / TEST Load Panel to terminal T1 on unit under test.

5.8.5.5 Setup Multimeter as follows:
- •200 Millivolts Scale
- •Volts DC
- •Connect positive (+) lead to terminal T1 on Contactor.
- •Connect negative (-) lead to terminal T2 on Contactor.

WARNING - HIGH CURRENT POTENTIAL - WARNING

5.8.5.6 Set Constant Current level using Dummy Load as follows: (Ref. Table 5.8-A)
- •Connect negative (-) lead of Current Load Panel to terminal T2 on DUMMY / TEST Load Panel.
- •Connect positive (+) lead of Current Load Panel to terminal T1 on DUMMY / TEST Load Panel.
- •Set DUMMY / Test switch to DUMMY.
- •Turn-on Current Load Panel.
- •Adjust Constant Current per Table 5.8-A.

5.8.5.7 Set PWR switch (S1) to CLOSED position.

5.8.5.8 Then set CONT switch (S2) to CLOSED position.

5.8.5.9 Apply Constant Current load to unit under test by setting the DUMMY / TEST switch to the TEST position.

5.8.5.10 Read Multimeter and record reading on Data Sheet.

5.8.5.11 Set DUMMY / TEST switch to DUMMY. Set CONT switch to the OPEN position.

5.8.5.12 Repeat steps 5.8.5.8 through 5.8.5.11 four (4) times.

5.8.5.13 Turn-off Current Load Panel. Reset all switches on Contactor Control Box to the OPEN Position. Disconnect all equipment. Contact Voltage Drop Test is complete.

CONTACT VOLTAGE DROP				
---	SM500H1		SM1000H1	
Test	Current Level Amp.	Max. Avg. CVD	Current Level Amp.	Max. Avg. CVD
Constant Current	500	.175 Volts	1000	.175 Volts

TABLE 5.8-A

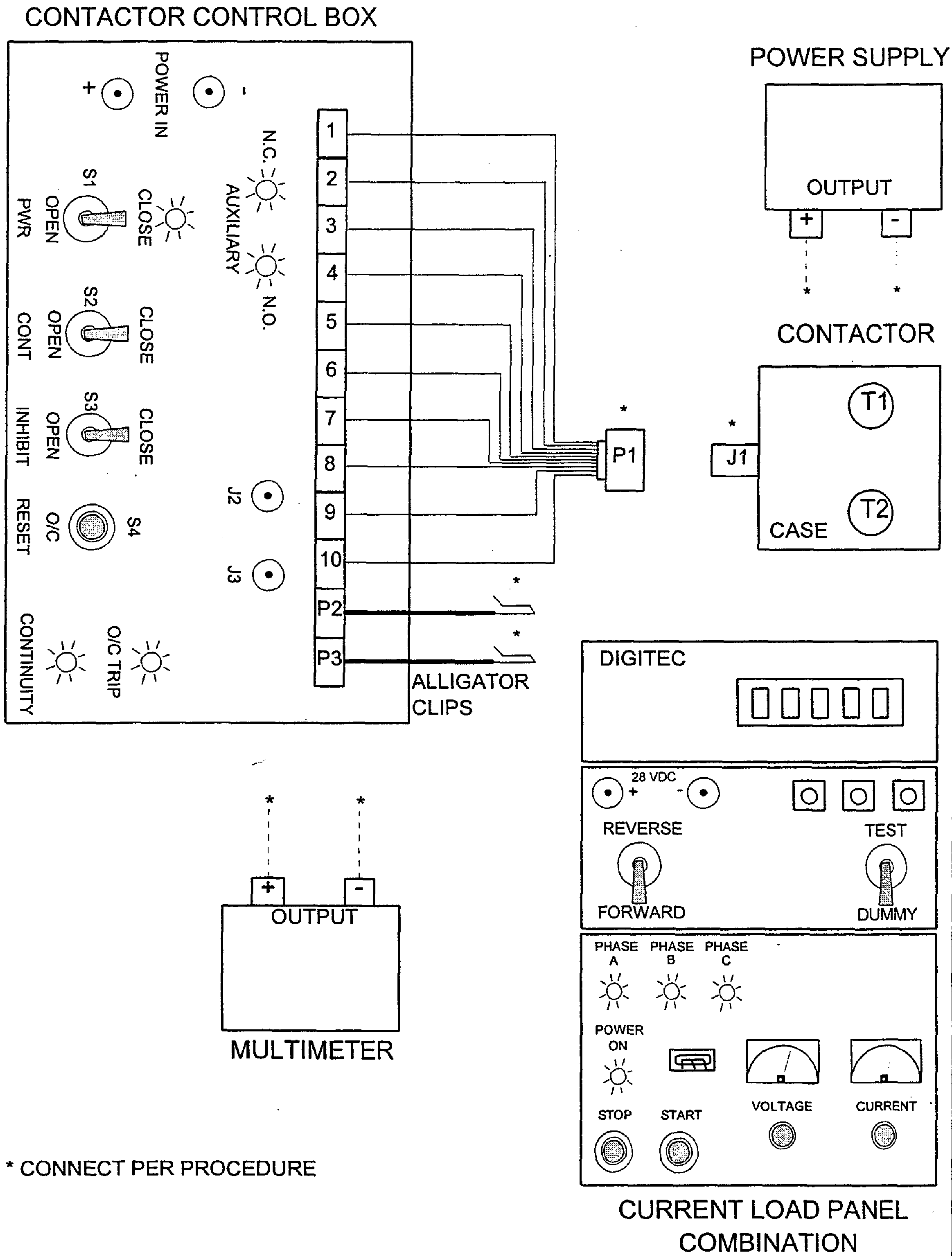


FIGURE 5.8-1

Contact Voltage Drop, Test Setup

5.9 LEAK TEST:

5.9.1 Purpose: To insure Contactor is properly sealed after assembly and test. This test is not to be substituted for the Helium leak test performed during manufacture. (MIL-STD-202, Method 112E, Procedure I, followed by Procedure IV except water is substituted for silicone oil.)

5.9.2 Test Equipment:
- Bell Jar Tester.
- Mating Plug for connector J1 with all holes plugged.

5.9.3 Power Requirements:
- None

5.9.4 General Requirements:

5.9.4.1 Test shall be performed at prevailing factory or laboratory ambient conditions.

5.9.4.2 Test equipment to be turned on for proper warm up time.

5.9.4.3 Verify test equipment is within calibration cycle.

5.9.4.5 Test procedure shall be in accordance with MIL-STD-202, Method 112E, Procedure IV, Test Condition B, except water is to be substituted for silicone oil.

5.9.5 Test Procedure: The following procedure shall be executed in sequence. Any observed leaks shall constitute a failure and will be cause for rejection of the Contactor under test. Reference Figure 5.9-1 for equipment setup graphic. Record Helium leak rate obtained during Production testing on test Data Sheet.

5.9.5.1 Assemble test plug to connector J1 on Contactor.

5.9.5.2 Set POWER switch on Bell Jar Tester to ON.

5.9.5.3 Place Contactor on moveable platform on Bell Jar Tester.

5.9.5.4 Lower Contactor into the water solution by closing lid and actuating TRAY switch to down position.

5.9.5.5 Cycle start switch to down position.

5.9.5.6 Observe Contactor for gross leaks (large bubbles rapidly escaping from interior of device). Record results on Data Sheet.

5.9.5.7 If bubbles exist, raise tray by moving the TRAY SWITCH to the UP position so that the Unit Under Test is above the surface of the water solution, then actuate CYCLE STOP switch to down position. Raise lid and remove Contactor. Contactor has failed and unit is rejected. If no bubbles were observed, continue with next step.

5.9.5.8 When gauge reads 28.5 inches of Hg, activate the 85 second timer. Green light on TIMER will light.

5.9.5.9 Observe Contactor for continuous stream of bubbles. Record results on Data Sheet. If bubbles exist, go to step 5.9.5.7.

5.9.5.10 After 85 seconds, the TIMER blue indicator comes on and 120 second TIMER period starts. (The blue light indicates that the Bell Jar vacuum has been reduced to 27.5 inches of Hg on gauge.)

5.9.5.11 Observe Contactor for continuous stream of bubbles. Record results on Data Sheet. If bubbles exist, go to step 5.9.5.7.

5.9.5.12 When both green and blue indicators have extinguished, test is complete.

5.9.5.13 Raise Contactor from water solution, open Bell Jar Lid, and remove Contactor from test chamber.

5.9.5.14 Blow off Contactor using air hose. Continue until no water residue is present.

5.9.5.15 Remove test connector plug from Contactor.

5.9.5.16 Allow unit under test to dry at room ambient conditions for one to two hours and then conduct the Dielectric Withstanding Voltage Test per Section 5.3 of this ATP. Record results on Data Sheet.

5.9.5.17 Leak Test is complete.

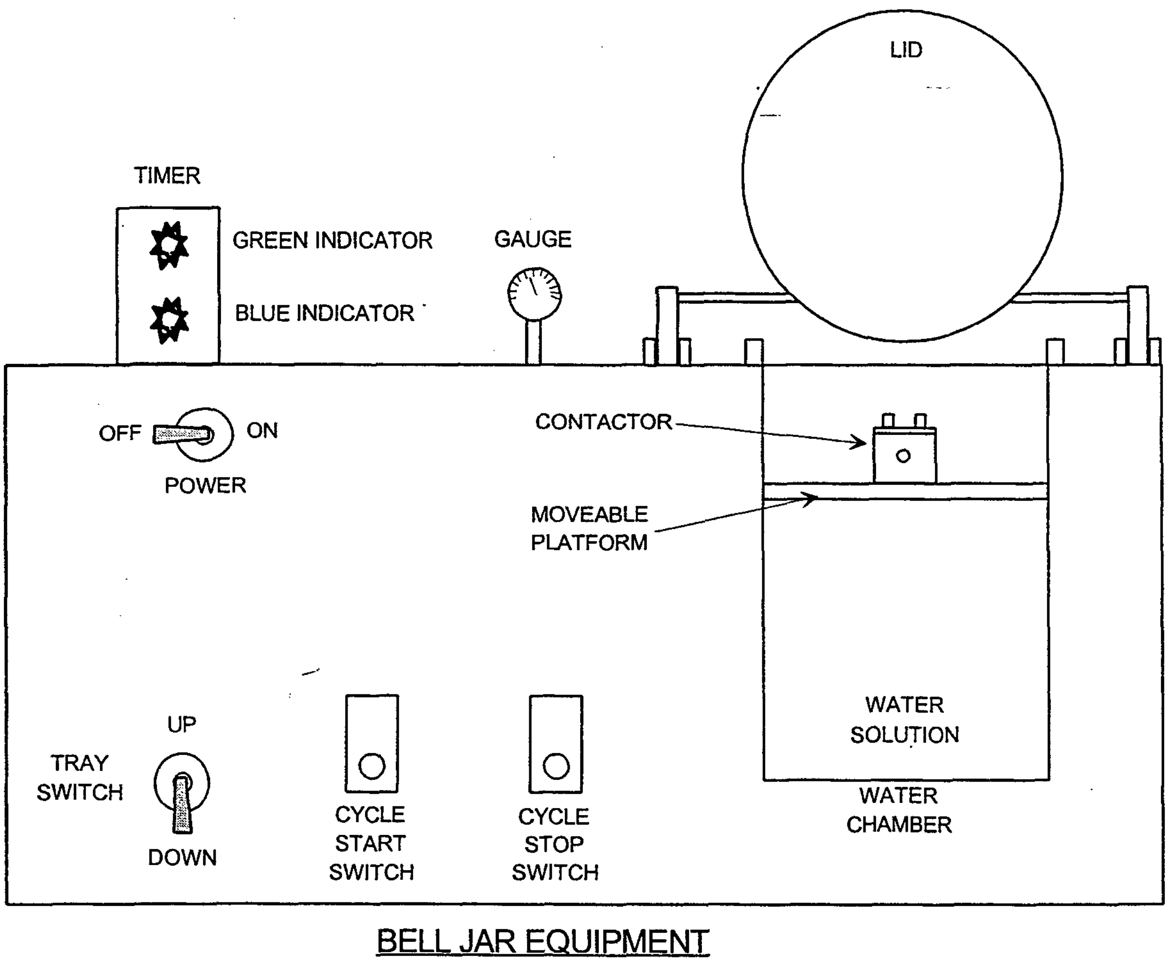


FIGURE 5.9-1

Leak Test Setup

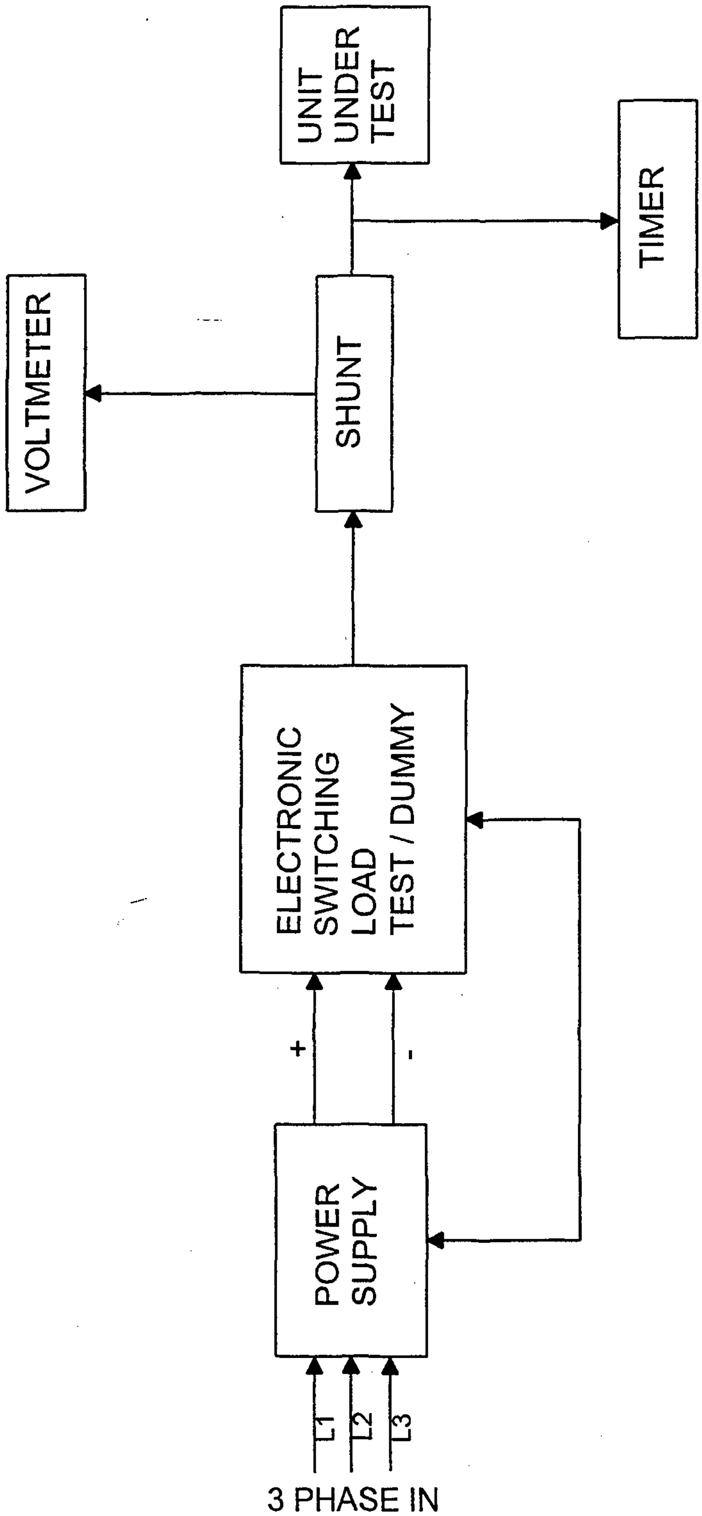
6.0 FAILURE REPORTING:

6.1 All failures will be reported to the procuring authority on a monthly basis.

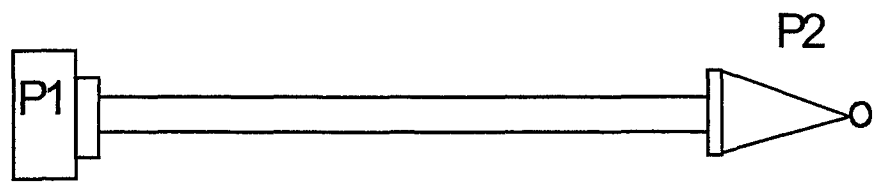
6.2 Failures and analysis of failures will be made part of the project record through inclusion in the quarterly Technical Operation Reports (TOR).

APPENDIX A-A

SPECIAL TEST EQUIPMENT



CURRENT LOAD PANEL



1. WIRE PER MIL-W-22759/7-9-22
2. P1 PLUG: TO MATE WITH D38999/25NB35PN
3. P2: BANANA PLUG

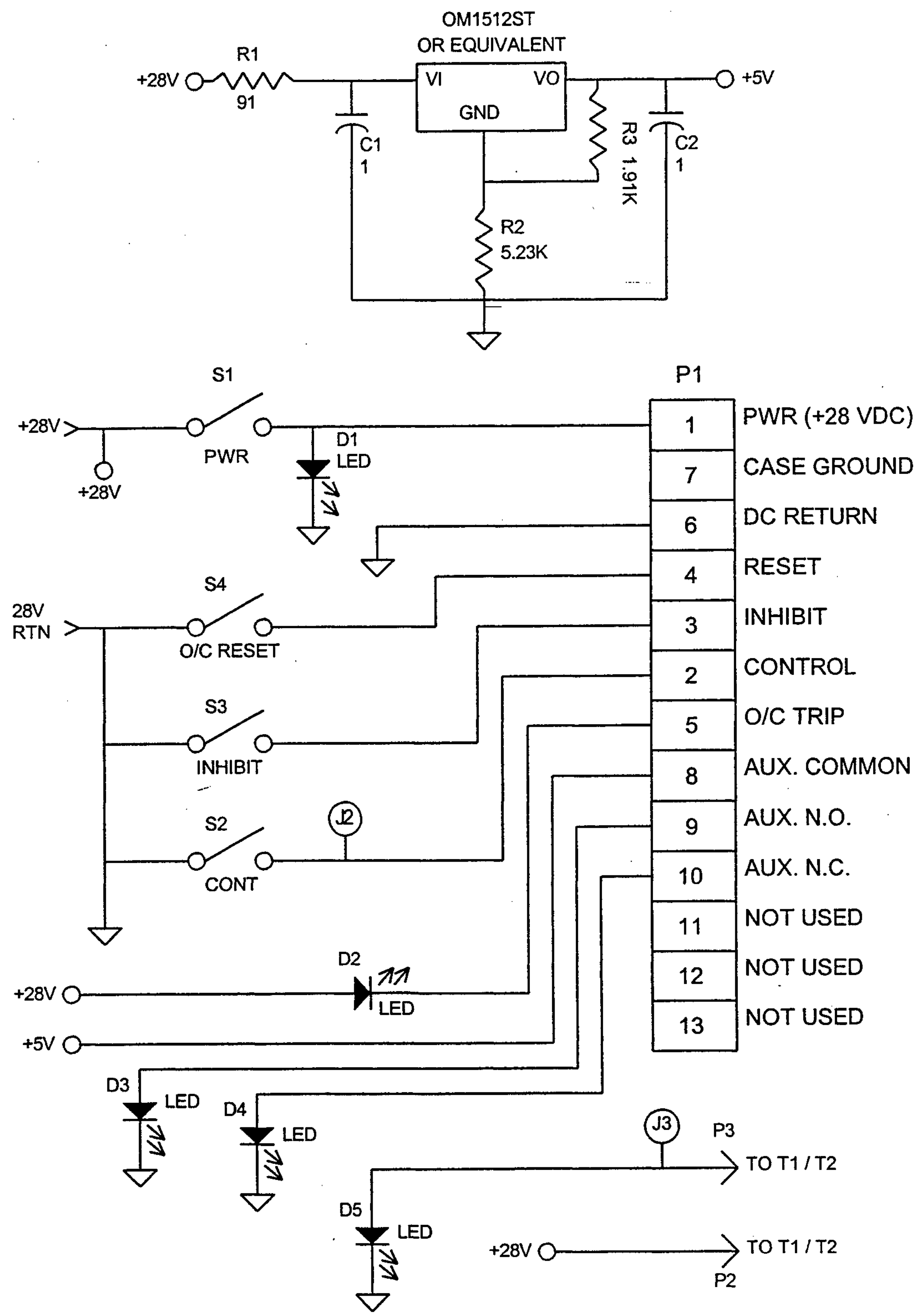
WIRE LIST

FROM	TO
P1-1	P2
P1-2	P2
P1-3	P2
P1-4	P2
P1-5	P2
P1-6	P2
P1-8	P2
P1-9	P2
P1-10	P2

P1-7 (CASE GROUND) IS NOT CONNECTED TO P2.
P1-11, P1-12, AND P1-13 ARE NOT USED.

CABLE ASSEMBLY

TNXXXXXX



CONTACTOR CONTROL BOX SCHEMATIC

TNXXXXXX

APPENDIX A-B

DATA SHEETS

A50-24885
Acceptance Test Procedure
Data Sheet

DESCRIPTION:									
PART NO.:				INSPECTED BY:				DATE:	
REVISION:				REVIEWED BY:				DATE:	
SERIAL NO.:				NUMBER OF OPERATIONS:					
VISUAL AND MECHANICAL EXAMINATION (PARA. 5.1)									
CERAMICS		CONNECTOR		THREADS		NAMEPLATE		MARKINGS	
PASS	FAIL	PASS	FAIL	PASS	FAIL	PASS	FAIL	PASS	FAIL
WORKMANSHIP		COMMENTS:						WEIGHT	
PASS	FAIL							SPEC.:	
								ACTUAL:	

PHYSICAL DIMENSIONS				
DIM. SYMBOL	SPECIFICATION & TOLERANCE	MEASUREMENT	HOW MEASURED	DEFECT MARK X
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				
11				
12				
13				
14				
15				
16				
17				
18				
19				
20				
21				
22				

A50-24885
Acceptance Test Procedure
Data Sheet

DESCRIPTION:		
PART NO.:	INSPECTED BY:	DATE:
SERIAL NO.:	REVIEWED BY:	DATE:

INSULATION RESISTANCE (PARA. 5.2)

EQUIPMENT AND CALIBRATION DATES

CASE GROUND VERIFICATION (PARA. 5.2.5.2)				TERM. T1 TO CASE (PARA. 5.2.5.5)		TERM T2 TO CASE (PARA. 5.2.5.6)		TERM T1 & T2 TO CASE (PARA. 5.2.5.8)	
PIN #6		PIN #7							
SHORT	OPEN	SHORT	OPEN	SPEC.	ACTUAL	SPEC.	ACTUAL	SPEC.	ACTUAL
				>100MEG		>100MEG		>100MEG	

TERM. T1 TO TERM. T2 (PARA. 5.2.5.10)		ELECTRONICS TO GROUND (PARA. 5.2.5.12)		COMMENTS:
SPEC.	ACTUAL	SPEC.	ACTUAL	
>100MEG		>100MEG		

DIELECTRIC WITHSTANDING VOLTAGE (PARA. 5.3)

INSPECTED BY:	DATE:	REVIEWED BY:	DATE:

EQUIPMENT AND CALIBRATION DATES

TERM. T1 TO CASE (PARA. 5.3.5.6)		TERM T2 TO CASE (PARA. 5.3.5.7)		TERM T1 & T2 TO CASE (PARA. 5.3.5.9)		TERM. T1 TO TERM. T2 (PARA. 5.3.5.11)		ELECTRONICS TO GROUND (PARA. 5.3.5.14)	
SPEC.	ACTUAL	SPEC.	ACTUAL	SPEC.	ACTUAL	SPEC.	ACTUAL	SPEC.	ACTUAL
<1mA		<1mA		<1mA		<1mA		<1mA	

COMMENTS:

<u>**A50-24885**</u>
<u>**Acceptance Test Procedure**</u>
<u>**Data Sheet**</u>

DESCRIPTION:		
PART NO.:	INSPECTED BY:	DATE:
SERIAL NO.:	REVIEWED BY:	DATE:

OPERATION / INHIBIT TEST (PARA. 5.4)

EQUIPMENT AND CALIBRATION DATES

SHADED AREAS INDICATE PROPER INDICATOR LIGHT OUTPUT

PWR (S1) CLOSED, CONT (S2) & INHIBIT (S3) OPEN (PARA. 5.4.5.4)

POWER LIGHT		AUXILIARY				CONTINUITY LIGHT		O/C TRIP LIGHT	
		N.O.		N.C.					
ON	OFF	ON	OFF	ON	OFF	ON	OFF	ON	OFF

PWR (S1) & CONT (S2) CLOSED, INHIBIT (S3) OPEN (PARA. 5.4.5.5)

POWER LIGHT		AUXILIARY				CONTINUITY LIGHT		O/C TRIP LIGHT	
		N.O.		N.C.					
ON	OFF	ON	OFF	ON	OFF	ON	OFF	ON	OFF

PWR (S1), CONT (S2) & INHIBIT (S3) CLOSED (PARA. 5.4.5.6)

POWER LIGHT		AUXILIARY				CONTINUITY LIGHT		O/C TRIP LIGHT	
		N.O.		N.C.					
ON	OFF	ON	OFF	ON	OFF	ON	OFF	ON	OFF

PWR (S1) & INHIBIT (S3) CLOSED, CONT (S2) OPEN (PARA. 5.4.5.7)

POWER LIGHT		AUXILIARY				CONTINUITY LIGHT		O/C TRIP LIGHT	
		N.O.		N.C.					
ON	OFF	ON	OFF	ON	OFF	ON	OFF	ON	OFF

PWR (S1) & CONT (S2) CLOSED, & INHIBIT OPEN (PARA. 5.4.5.8)

POWER LIGHT		AUXILIARY				CONTINUITY LIGHT		O/C TRIP LIGHT	
		N.O.		N.C.					
ON	OFF	ON	OFF	ON	OFF	ON	OFF	ON	OFF

A50-24885
Acceptance Test Procedure
Data Sheet

DESCRIPTION:		
PART NO.:	INSPECTED BY:	DATE:
SERIAL NO.:	REVIEWED BY:	DATE:

OPERATE / INHIBIT TEST (PARA. 5.4) CONT'D

PWR (S1) CLOSED, CONT (S2) & INHIBIT (S3) OPEN (PARA. 5.4.5.9)

POWER LIGHT		AUXILIARY				CONTINUITY LIGHT		O/C TRIP LIGHT	
		N.O.		N.C.					
ON	OFF	ON	OFF	ON	OFF	ON	OFF	ON	OFF

PWR (S1) & CONT (S2) CLOSED, INHIBIT (S3) OPEN (PARA. 5.4.5.10)

POWER LIGHT		AUXILIARY				CONTINUITY LIGHT		O/C TRIP LIGHT	
		N.O.		N.C.					
ON	OFF	ON	OFF	ON	OFF	ON	OFF	ON	OFF

UNDER VOLTAGE TEST, 15.9 VDC (PARA. 5.4.5.12)
PWR (S1) & CONT (S2) CLOSED

POWER LIGHT		AUXILIARY				CONTINUITY LIGHT		O/C TRIP LIGHT	
		N.O.		N.C.					
ON	OFF	ON	OFF	ON	OFF	ON	OFF	ON	OFF

MINIMUM VOLTAGE TEST, 16.1 VDC (PARA. 5.4.5.14)
PWR (S1) & CONT (S2) CLOSED

POWER LIGHT		AUXILIARY				CONTINUITY LIGHT		O/C TRIP LIGHT	
		N.O.		N.C.					
ON	OFF	ON	OFF	ON	OFF	ON	OFF	ON	OFF

COMMENTS:

A50-24885
Acceptance Test Procedure
Data Sheet

SHEET 5 OF 7

DESCRIPTION:		
PART NO.:	INSPECTED BY:	DATE:
SERIAL NO.:	REVIEWED BY:	DATE:

OPERATE AND RELEASE TIMES (PARA. 5.5)

EQUIPMENT AND CALIBRATION DATES

CONTINUITY LIGHT		OPERATE TIME		RELEASE TIME	
		SPECIFICATION	MEASUREMENT	SPECIFICATION	MEASUREMENT
ON	OFF	TBD		TBD	

COMMENTS

Attach copy of scope traces to this report.

CONTACT BOUNCE (PARA. 5.6)

EQUIPMENT AND CALIBRATION DATES

CONTINUITY LIGHT			CONTACT BOUNCE MEASUREMENTS (PARA. 5.6.5.6)						
			#1	#2	#3	#4	#5	AVG.	SPEC.
ON	OFF								TBD

COMMENTS

Attach copy of scope traces to this report.

Acceptance Test Procedure

Data Sheet

REV B 9/16/96 SHEET 6 OF 7

DESCRIPTION:		
PART NO.:	INSPECTED BY:	DATE:
SERIAL NO.:	REVIEWED BY:	DATE:

TRIP CHARACTERISTICS (PARA. 5.7)

EQUIPMENT AND CALIBRATION DATES

CONSTANT CURRENT					TRIP CURRENT #1				
SPEC.	+ ON T1	+ ON T2	O/C TRIP LIGHT		SPEC.	+ ON T1	+ ON T2	O/C TRIP LIGHT	
NO TRIP			NO	YES	TBD			NO	YES

TRIP CURRENT #2					TRIP CURRENT #3				
SPEC.	+ ON T1	+ ON T2	O/C TRIP LIGHT		SPEC.	+ ON T1	+ ON T2	O/C TRIP LIGHT	
TBD			NO	YES	TBD			NO	YES

TRIP CURRENT #4					TRIP CURRENT #5				
SPEC.	+ ON T1	+ ON T2	O/C TRIP LIGHT		SPEC.	+ ON T1	+ ON T2	O/C TRIP LIGHT	
TBD			NO	YES	TBD			NO	YES

COMMENTS

WRITE PASS/FAIL NEXT TO ALL TEST ROWS

CONTACT RESISTANCE TEST (PARA. 5.8)

EQUIPMENT AND CALIBRATION DATES

CONTACT RESISTANCE MEASUREMENTS							
#1	#2	#3	#4	#5	AVG.	SPEC.	HIGHEST
						.175 Volts Max.	

COMMENTS

DESCRIPTION:		
PART NO.:	INSPECTED BY:	DATE:
SERIAL NO.:	REVIEWED BY:	DATE:

LEAK TEST (PARA. 5.9)

EQUIPMENT AND CALIBRATION DATES

PRODUCTION HELIUM LEAK RATE		BELL JAR LEAK (PARA. 5.9.5.6)		BELL JAR LEAK (PARA. 5.9.5.9)		BELL JAR LEAK (PARA. 5.9.5.11)	
SPEC.	TBD	PASS	FAIL	PASS	FAIL	PASS	FAIL
ACTUAL							

POST BELL JAR DIELECTRIC WITHSTANDING VOLTAGE TEST (PARA. 5.3)

INSPECTED BY:	DATE:	REVIEWED BY:	DATE:

EQUIPMENT AND CALIBRATION DATES

TERM. T1 TO CASE (PARA. 5.3.5.6)		TERM T2 TO CASE (PARA. 5.3.5.9)		TERM. T1 TO TERM. T2 (PARA. 5.3.5.11)		ELECTRONICS TO GROUND (PARA. 5.3.5.14)	
SPEC.	ACTUAL	SPEC.	ACTUAL	SPEC.	ACTUAL	SPEC.	ACTUAL
<1mA		<1mA		<1mA		<1mA	

COMMENTS

Appendix B

Test Plan and Procedure

Eaton Corporation of Florida
Aerospace Controls Division
Sarasota Plant
2250 Whitfield Avenue
Sarasota, Fl 34243

Eaton Project No. DV95-6698

TEST PLAN AND PROCEDURE
A50-24888
CONTACTOR WITH CURRENT SENSING
270 Vdc, 500/1000 AMPERES
EATON P/N SM500H1/SM1000H1

Prepared By: A. T. Nelson Date: 7-24-96
A. T. Nelson, Engineering Assistant

Edited By: Karl Kitts Date: 7-24-96
K. Kitts, Prod. Dev. Engineer

Approved By: Karl Kitts for WB Halbeck Date: 7-24-96
W. B. Halbeck, Engineering Manager

Approved By: Tim Kostelnitz for Date: 7-24-96
L. R. Eslinger, Quality Assurance Engineer

Approved By:__________ Date:________
D. R. Timm, Program Manager

Department of The Air Force
Air Force Material Command (ASC)
Wright Laboratory (WL/POKA)
Wright-Patterson AFB, OH 45433-7607

THE PURPOSE OF THIS SHEET IS TO RECORD THE LATEST REVISION LETTERS OF DOCUMENTS WITH TWO OR MORE SHEETS. SEE APPROPRIATE COLUMNS FOR SHEET NUMBER AND REVISION LETTER OF THAT SHEET.

REVISION BLOCK FOR THIS SHEET ONLY

REV	DESCRIPTION	DATE	DFTG	APPR	REV	DESCRIPTION	DATE	DFTG	APPR
A	Added para 6.11.5.15, and 6.12.5.15. Corrected para sequence 6.13.5.13 to 5.13.5.17. Corrected para 6.14.5.19 reference to 6.14.5.20.	9/23 1996							
B	Modified para 6.1.5.10 to include oscilloscope traces for both contact closing and opening.	11/12 1996							

CURRENT REVISION LEVEL OF INDIVIDUAL SHEETS

SHT	REV	SHT	REV	SHT	REV	SHT	REV	SHT	REV	SHT	REV	SHT	REV	SHT	REV	SHT	REV
2		14		26		38		50	A	62							
3		15		27		39		51		63							
4		16		28		40		52		64							
5		17		29		41		53	A	65							
6		18		30		42		54	A								
7		19		31		43		55									
8		20		32		44		56									
9		21		33		45		57									
10	A	22		34		46		58	A								
11		23		35		47	A	59									
12		24		36		48		60									
13		25		37		49		61									

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1.0 INTRODUCTION:

1.1 Scope: This Test Plan / Procedure (TP), Eaton drawing number A50-24888, has been prepared by Eaton Corporation, Aerospace Controls Division, for the Department of the Air Force, Air Force Material Command, Wright Laboratory, Wright-Patterson AFB, Ohio. This TP establishes the requirements for prototype design verification testing of a SPST, 270 VDC, 500 or 1000 Ampere contactor being designed under contract number F33615-93-C-2359.

1.2 Purpose:

1.2.1 This TP serves as a framework for planning and conducting the necessary environmental, functional, and electrical tests for verification of contactor performance.

1.2.2 Verification of the contactor performance shall be accomplished according to the following guidelines.

1.2.2.1 All contactors produced are to be subjected to this TP for design verification testing as required by the subject contract. All testing shall be performed in the order presented.

1.2.2.2 All contactors must meet the test requirements stated herein unless deviation is granted by the procuring authority.

1.2.2.3 No contactor will be sealed until after the verification testing outlined herein is completed and the final test report is approved by the procuring authority.

2.0 APPLICABLE DOCUMENTS:

2.1 Referenced Documents: The following documents of the issue in effect form a part of this document to the extent specified herein. In the event of conflict, this document shall take precedence.

Military

MIL-STD-202	Test Methods for Electronic and Electrical Component Parts
MIL-R-6106J	Relays, Electromagnetic (Including Established Reliability (ER) Types), General Specification for
F33615-93-C-2359	Contract Section C, Description/Specification Dated 30 August 1993, as Amended 26 September 1995.

Commercial

SM1000H1& SM500H1 — Suppliers Drawing, SPST Contactor, 270 VDC, 500/1000 Amperes, With Current Sensing

A50-24885 — Suppliers Acceptance Test Procedure (ATP)

3.0 <u>OUTLINE OF TESTS:</u> All tests are to be performed per Table 3.0-A. Testing shall be performed in the order specified. Some testing, such as Insulation Resistance, Dielectric Withstanding Voltage, Operate and Release Times, etc. will be repeated during planned interruptions of specified tests. These exceptions are outlined in the individual test requirements.

4.0 <u>LIST OF TEST EQUIPMENT:</u>

NAME	MANUFACTURER	MODEL NO.	ALTERNATE EQUIPMENT
DC Power Supply	Lambda	LLS9040	or equivalent
Multimeter	Fluke	8840A	or equivalent
Oscilloscope Dual Trace Memory	Tektronic	Model 5441	or equivalent
Voltage Isolator	Tektronic	Model A6902B	or equivalent
Contactor Control Box	Special Test Equipment	EATON TN190943	or equivalent
Current Load Panel	Special Test Equipment	EATON TNXXXXX	or equivalent
Shock/Vibration Apparatus	Special Test Equipment	EATON TNXXXXX	or equivalent
Computer & Input/Output Card	Special Test Equipment	EATON TNXXXXX	or equivalent
Printer/Scope Camera	Special Test Equipment	EATON TNXXXXX	or equivalent
Mounting Fixture	Special Test Equipment	EATON TNXXXXX	or equivalent
Torque Wrench	Special Test Equipment	EATON TNXXXXX	or equivalent
Pull Force Device	Special Test Equipment	EATON TNXXXXX	or equivalent
Temperature/Altitude Chamber	Special Test Equipment	EATON TNXXXXX	or equivalent
Themocouple Temperature Recorder	Special Test Equipment	EATON TNXXXXX	or equivalent
Contact/Chatter Monitor	Special Test Equipment	EATON TNXXXXX	or equivalent

TABLE 3.0-A

Inspection / test	Specification or Procedure	Require-ment Para.	Test Para.	Test Sequence						Test Location
				Contactor Serial Number						
				#1	#2	#3	#4	#5	#6	
Visual & Mechanical	A50-24885	5.1.4	5.1.5	1	1	1	1	1	1	A
Insulation Resistance	A50-24885	5.2.4	5.2.5	2	2	2	2	2	2	A
Dielectric Withstanding Voltage	A50-24885	5.3.4	5.3.5	3	3	3	3	3	3	A
Operation / Inhibit Test	A50-24885	5.4.4	5.4.5	4	4	4	4	4	4	A
Operate and Release Times	A50-24885	5.5.4	5.5.5	5	5	5	5	5	5	A
Contact Bounce	A50-24885	5.6.4	5.6.5	6	6	6	6	6	6	A
Trip Characteristics	A50-24885	5.7.4	5.7.5		7	7		7	7	A
Contact Resistance	A50-24885	5.8.4	5.8.5	7	8	8	7	8	8	A
Seal	A50-24885	5.9.4	5.9.5	8						A
Arc Time Measurements 270VDC at Rated Currents	A50-24888	6.1.4	6.1.5	9	9	9	8	9	9	A
High Temperature Operation	A50-24888	6.2.4	6.2.5	10	10	10	9	10	10	A
Low Temperature Operation	A50-24888	6.3.4	6.3.5	11	11	11	10	11	11	A
Thermal Shock	A50-24888	6.4.4	6.4.5	12						A
Strength of Terminals	A50-24888	6.5.4	6.5.5	13						A
Continuous Current (500 Ampere)	A50-24888	6.6.4	6.6.5	14	12		11	12		A
Continuous Current (1000 Amperes)	A50-24888	6.7.4	6.7.5	15		12	12		12	A
Shock	A50-24888	6.8.4	6.8.5	16	*	**	**	*	**	A
Vibration	A50-24888	6.9.4	6.9.5	17	*	**	**	*	**	A
Mechanical Life (endurance at reduced load)	A50-24888	6.10.4	6.10.5					13		A
Electrical Life (1000 A)	A50-24888	6.11.4	6.11.5		–	13				A
Electrical Life (500 A)	A50-24888	6.12.4	6.12.5		13					A
Rupture	A50-24888	6.13.4	6.13.5				13			B
Electrical at Altitude	A50-24888	6.14.4	6.14.5						13	A
Seal	A50-24885	5.9.4	5.9.5	18	*	**	**	*	**	A

* = These tests, on these units, will not be performed until after all other testing is completed, the Test Report is approved by the Air Force, and units 2 and 5 are rebuilt, sealed, and prepared for shipment. Vibration test will be limited to two scans. (One up, one down)

**= Final action is based upon TBD disposition by the Air Force.

5.0 CONSTRUCTION SUMMARY: The following summary is included to provide a clear understanding of the test procedure that follows. Three constructions are covered by this procedure.

5.1 Serial Numbers 1 and 4: These two units are mechanically constructed as 1000 Ampere designs with no current sensing. Electronics required to control the pulsed coil motors, that open and close the main contacts, are located external to the unit for test purposes.

5.2 Serial Numbers 2 and 5: These two units are mechanically constructed as 1000 Ampere designs with current sensing. Electronics are included to control the pulsed coil motors, that open and close the main contacts of the contactor, and to provide current sensing functionality. The current sensing electronics in these two units are designed and calibrated for a current level of 500 Amperes.

5.3 Serial Numbers 3 and 6: These two units are mechanically constructed as 1000 Ampere designs with current sensing. Electronics are included to control the pulsed coil motors, that open and close the main contacts of the contactor, and to provide current sensing functionality. The current sensing electronics in these two units are designed and calibrated for a current level of 1000 Amperes.

TABLE 3.0-A Continued

TEST LOCATIONS:

A = Eaton Corporation of Florida
Aerospace Controls Division
Sarasota Plant
2250 Whitfield Avenue
Sarasota, FL 34243

B = Eaton Corporation
Corporate Research and Development
4201 North 27th Street
Milwaukee, WI 53216

6.0 TEST PROCEDURES:

6.1 ARC TIME MEASUREMENTS:

6.1.1 Purpose: These measurements are made to characterize the individual contactors being submitted for testing (DUT). Scope traces provide arc times, open circuit voltage, arc current level, and a visual representation of arc movement into and through the arc splitter plates. The scope picture also provides a visual representation of the arc's tendency to remake / re-establish itself (strike-back). This data is useful in evaluating degradation of the contactor during testing and after test.

6.1.2 Test Equipment:

- Oscilloscope Tektronic Model 5441 or equivalent
- Voltage Isolator Tektronic Model A6902B or equivalent
- High Voltage Power Supply/Load Panel Eaton P/N TNXXXXXX
- Test Chamber Eaton P/N TNXXXXXX
- DC Power Supply (control) Lambda LLS9040 or equivalent
- Contactor Control Box Eaton P/N TN190943
- Computer and input /output card
- Printer / Scope camera for recording scope traces
- Power hookup cables sized for applicable currents (Reference individual contactor requirements)

6.1.3 Power Requirements:

- Line power, 270Vdc, 500 or 1000A (Reference individual contactor requirements)
- Contactor control 28Vdc

6.1.4 General Requirements:

6.1.4.1 Test shall be performed at prevailing factory or laboratory ambient conditions.

6.1.4.2 Verify test equipment is within calibration cycle.

6.1.4.3 Test equipment to be turned on for approximately thirty minutes warm up time.

6.1.5 Test Procedure: The following procedure shall be executed in sequence. Reference Figure 6.1-1 for equipment setup graphic.

6.1.5.1 Setup contactor control box and power supply as follows:

- Connect P1 of contactor control box to J1 on contactor.
- Connect P17 of contactor control box across control relay terminals.
- Connect negative (-) lead of power supply to negative (-) POWER IN terminal on contactor control box.
- Connect positive (+) lead of power supply to positive (+) POWER IN terminal on contactor control box.

6.1.5.2 Turn-on control power supply and set voltage to 28Vdc.

6.1.5.3 Turn-on high-voltage power supply and set voltage to 270Vdc.

6.1.5.4 Set PWR switch (S1) on contactor control box to CLOSE.

6.1.5.5 Set test current to 500/1000A (Reference individual contactor requirements).

6.1.5.6 Set CONT switch (S2) on contactor control box to OPEN. CONTINUITY indicator light on contactor control box should NOT be illuminated.

6.1.5.7 Setup oscilloscope as follows:

- Connect channel A on oscilloscope to channel A on voltage isolator. Set channel A on oscilloscope to 100mv/div and channel A on voltage isolator to 20mv:100mv.
- Connect channel B on oscilloscope to channel B on voltage isolator. Set channel B on oscilloscope to 100mv/div and channel B on voltage isolator to 200v:100mv to expect approximately 140mv deflection.
- On oscilloscope set controls for memory, time interval, channel B trig at 70mv level rising edge.
- Connect channel A of the voltage isolator across the appropriate 500A/100mv or 1000A/100mv shunt and channel B of the voltage isolator across the contactor.

6.1.5.8 Initiate computer test sequence and set length of the test cycle to five (5) operations with .1 second on time and approximately 60 seconds off time.

6.1.5.9 Set CONT switch (S2) on contactor control box to CLOSE position.

6.1.5.10 Read oscilloscope, create and label a hard-copy of (1) contact closure including any evident contact bounce (2) contact opening including the arc-time measurement. The arc time measured upon contact opening should not exceed 5ms. Labeling should include date of test, DUT identification number, polarity, and operation cycle.

6.1.5.11 Repeat steps 6.1.5.2 through 6.1.5.10 for a sub-total of five (5) operations.

6.1.5.12 Turn off control and high voltage power supplies.

6.1.5.13 Reverse power cables connected to DUT terminals T1 and T2 in order to reverse direction of current flow.

6.1.5.14 Repeat steps 6.1.5.2 through 6.1.5.10 for a grand total of ten (10) operations (five operations in each direction).

6.1.5.15 Turn off control and high voltage power supplies.

6.1.5.16 Disconnect all test equipment, arc time measurement is complete.

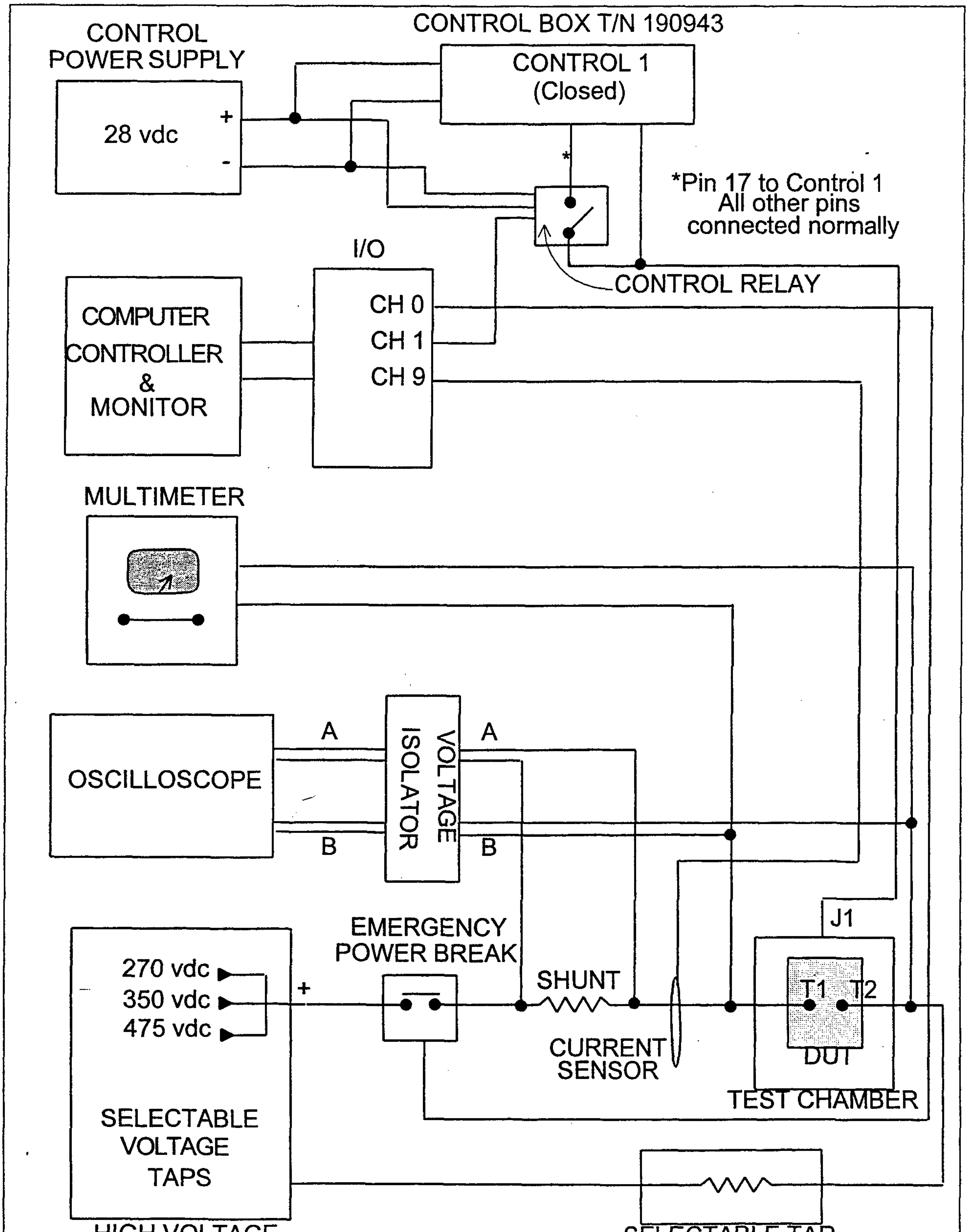


Figure 6.1-1
Arc Time, Test Setup

6.2 HIGH TEMPERATURE OPERATION:

6.2.1 Purpose: These measurements are made to characterize the individual contactor's performance during and after exposure to the high temperature specification limit of 71°C for devices with current sensing and 100°C for devices without current sensing. Scope traces provide arc times, open circuit voltage, arc current level, and a visual picture of arc movement into and through the arc splitter plates. The scope picture also provides a visual representation of the arc's tendency to remake / re-establish itself (strike-back). This data is useful in evaluating degradation of the contactor during testing and after test. Test and post-test ATP data provides performance data such as, operate and release times, contact bounce, dielectric, insulation and contact resistance measurement.

6.2.2 Test Equipment:

- Oscilloscope Tektronic Model 5441 or equivalent
- Voltage Isolator Tektronic Model A6902B or equivalent
- High Voltage Power Supply/Load Panel Eaton P/N TNXXXXXX
- Test Chamber Eaton P/N TNXXXXXX
- DC Power Supply (control) Lambda LLS9040 or equivalent
- Contactor Control Box Eaton P/N TN190943
- Computer with input/output card
- Printer/Scope camera for recording scope traces
- Power hookup cables sized for applicable currents (Reference individual contactor requirements)

6.2.3 Power Requirements:

- Line power, 270Vdc, 500 or 1000A (Reference individual contactor requirements)
- Contactor control, 28Vdc
- Operating power for high and low temperature test chamber (110VAC / 220VAC)

6.2.4 General Requirements:

6.2.4.1 Test shall be performed at 71°C for devices with current sensing and 100°C for devices without current sensing and at prevailing factory or laboratory ambient conditions.

6.2.4.2 Verify test equipment is within calibration cycle.

6.2.4.3 Test equipment to be turned on for approximately thirty minutes warm up time.

6.2.5 <u>Test Procedure:</u> The following procedure shall be executed in sequence. Reference Figure 6.2-1 for equipment setup graphic.

6.2.5.1 Setup contactor control box and power supply as follows:
- Connect P1 of contactor control box to J1 on contactor.
- Connect P17 of contactor control box across control relay terminals.
- Connect negative (-) lead of power supply to negative (-) POWER IN terminal on contactor control box.
- Connect positive (+) lead of power supply to positive (+) POWER IN terminal on contactor control box.

6.2.5.2 Turn-on control power supply and set voltage to 28Vdc.

6.2.5.3 With DUT in test chamber, raise and stabilize temperature of chamber to 71°C.

6.2.5.4 Turn-on high-voltage power supply and set voltage to 270Vdc.

6.2.5.5 Set PWR switch (S1) on contactor control box to CLOSE.

6.2.5.6 Set CONT switch (S2) on contactor control Box to OPEN. CONTINUITY indicator light on contactor control box should NOT be illuminated.

6.2.5.7 Setup oscilloscope as follows:
- Connect channel A on oscilloscope to channel A on voltage isolator. Set channel A on oscilloscope to 100mv/div and channel A on voltage isolator to 20mv:100mv.
- Connect channel B on oscilloscope to channel B on voltage isolator. Set channel B on oscilloscope to 100mv/div and channel B on voltage isolator to 200v:100mv to expect approximately 140mv deflection.
- On oscilloscope set controls for memory, time interval, channel B trig at 70mv level rising edge.
- Connect channel A of the voltage isolator across the appropriate 500A/100mv or 1000A/100mv shunt and channel B of the voltage isolator across the contactor.

6.2.5.8 Initiate computer test sequence and set length of the test cycle to one (1) operation with .1 second on time and approximately 60 seconds off time.

6.2.5.9 Set CONT switch (S2) on contactor control box to CLOSE position.

6.2.5.10 Read oscilloscope, create and label a hard-copy of the arc-time measurement. The time measured should not exceed 5ms. Labeling should include date of test, DUT identification number, polarity, and operation cycle.

6.2.5.11 Turn off control and high voltage power supplies.

6.2.5.12 Reverse power cables connected to DUT terminals T1 and T2 in order to reverse direction of current flow.

6.2.5.13 Repeat steps 6.2.5.2 through 6.2.5.10 for a total of one (1) cycle (each direction).

6.2.5.14 Turn off high voltage power supply.

6.2.5.15 While at high temperature complete the following performance tests according to the Acceptance Test Procedure A50-24885 (Eaton P/N SM500H1/SM1000H1) and record data on appropriate data sheets.

6.2.5.15.1 Conduct Operation/Inhibit Test per A50-24885, Para. 5.4.5

6.2.5.15.2 Conduct Operate and Release Times per A50-24885, Para. 5.5.5

6.2.5.15.3 Conduct Contact Bounce per A50-24885, Para. 5.6.5

6.2.5.16 Allow unit under test to lower and stabilize at room ambient temperature and complete the following performance post-tests according to the Acceptance Test Procedure A50-24885 (Eaton P/N SM500H1/SM1000H1) and record data on appropriate data sheets.

6.2.5.16.1 Conduct Insulation Resistance per A50-24885, Para. 5.2.5

6.2.5.16.2 Conduct Dielectric Withstanding Voltage per A50-24885, Para. 5.3.5

6.2.5.16.3 Conduct Contact Resistance per A50-24885, Para. 5.8.5

6.2.5.17 Disconnect all test equipment, high temperature operation is complete.

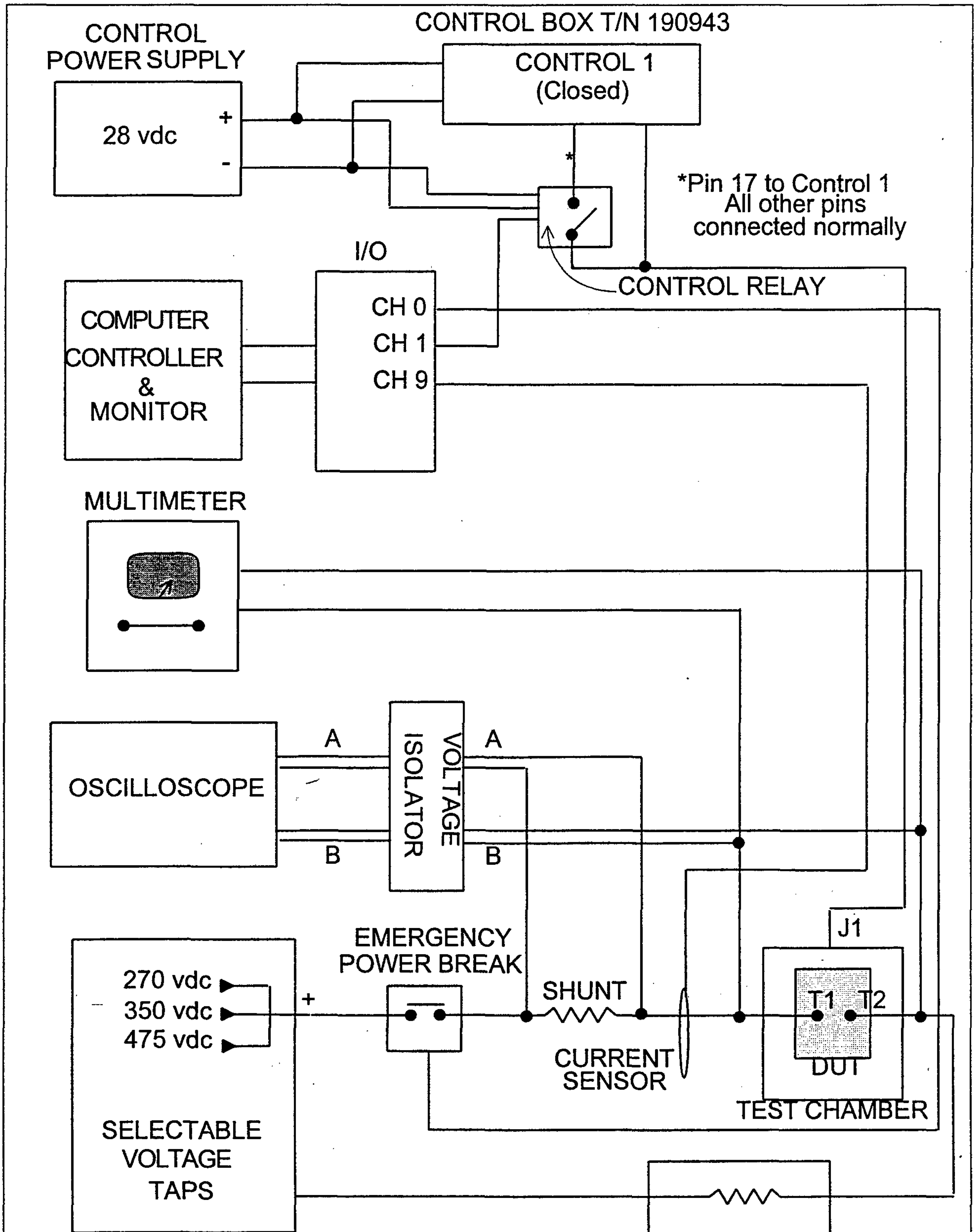


FIGURE 6.2-1
High Temperature, Test Setup

6.3 LOW TEMPERATURE OPERATION:

6.3.1 Purpose: These measurements are made to characterize the individual contactor's performance during and after exposure to the low temperature specification limit of -55°C. Scope traces provide arc times, open circuit voltage, arc current level, and a visual picture of arc movement into and through the arc splitter plates. The scope picture also provides a visual representation of the arc's tendency to remake / re-establish itself (strike-back). This data is useful in evaluating degradation of the contactor during testing and after test. Test and post-test ATP data provides performance data such as, operate and release times, contact bounce, dielectric and insulation resistance measurement, and contact resistance.

6.3.2 Test Equipment:

- Oscilloscope Tektronic Model 5441 or equivalent
- Voltage Isolator Tektronic Model A6902B or equivalent
- High Voltage Power Supply/Load Panel Eaton P/N TNXXXXXX
- Test Chamber Eaton P/N TNXXXXXX
- DC Power Supply (control) Lambda LLS9040 or equivalent
- Contactor Control Box Eaton P/N TN190943
- Computer with input/output card
- Printer/Scope camera for recording scope traces
- Power hookup cables sized for applicable currents (Reference individual contactor requirements)

6.3.3 Power Requirements:

- Line power, 270Vdc, 500 or 1000A (Reference individual contactor requirements)
- Contactor control, 28Vdc
- Operating power for high and low temperature test chamber (110VAC / 220VAC)

6.3.4 General Requirements:

6.3.4.1 Test shall be performed at -55°C and at prevailing factory or laboratory ambient conditions.

6.3.4.2 Verify test equipment is within calibration cycle.

6.3.4.3 Test equipment to be turned on for approximately thirty minutes warm up time.

6.3.5 Test Procedure: The following procedure shall be executed in sequence. Reference Figure 6.3-1 for equipment setup graphic.

6.3.5.1 Setup contactor control box and power supply as follows:

- Connect P1 of contactor control box to J1 on contactor.
- Connect P17 of contactor control box across control relay terminals.
- Connect negative (-) lead of power supply to negative (-) POWER IN terminal on contactor control box.
- Connect positive (+) lead of power supply to positive (+) POWER IN terminal on contactor control box.

6.3.5.2 Turn-on control power supply and set voltage to 28Vdc.

6.3.5.3 With DUT in test chamber, lower and stabilize temperature of chamber to -55°C.

6.3.5.4 Turn-on high-voltage power supply and set voltage to 270Vdc.

6.3.5.5 Set PWR switch (S1) on contactor control box to CLOSE.

6.3.5.6 Set CONT switch (S2) on contactor control box to OPEN. CONTINUITY indicator light on contactor control box should NOT be illuminated.

6.3.5.7 Setup oscilloscope as follows:

- Connect channel A on oscilloscope to channel A on voltage isolator. Set channel A on oscilloscope to 100mv/div and channel A on voltage isolator to 20mv:100mv.
- Connect channel B on oscilloscope to channel B on voltage isolator. Set channel B on oscilloscope to 100mv/div and channel B on voltage isolator to 200v:100mv to expect approximately 140mv deflection.
- On oscilloscope set controls for memory, time interval, channel B trig at 70mv level rising edge.
- Connect channel A of the voltage isolator across the appropriate 500A/100mv or 1000A/100mv shunt and channel B of the voltage isolator across the contactor.

6.3.5.8 Initiate computer test sequence and set length of the test cycle to one (1) operation with .1 second on time and approximately 60 seconds off time.

6.3.5.9 Set CONT switch (S2) on contactor control box to CLOSE position.

6.3.5.10 Read oscilloscope, create and label a hard-copy of the arc-time measurement. The time measured should not exceed 5ms. Labeling should include date of test, DUT identification number, polarity, and operation cycle.

6.3.5.11 Turn off control and high voltage power supplies.

6.3.5.12 Reverse power cables connected to DUT terminals T1 and T2 in order to reverse direction of current flow.

6.3.5.13 Repeat steps 6.3.5.2 through 6.3.5.10 for a total of one (1) cycle (each direction).

6.3.5.14 Turn off high voltage power supply.

6.3.5.15 While at low temperature complete the following performance tests according to the Acceptance Test Procedure A50-24885 (Eaton P/N SM500H1/SM1000H1) and record data on appropriate data sheets.

6.3.5.15.1 Conduct Operation/Inhibit Test per A50-24885, Para. 5.4.5

6.3.5.15.2 Conduct Operate and Release Times per A50-24885, Para. 5.5.5

6.3.5.15.3 Conduct Contact Bounce per A50-24885, Para. 5.6.5

6.3.5.16 Allow unit under test to raise and stabilize at room ambient temperature and complete the following performance post-tests according to the Acceptance Test Procedure A50-24885 (Eaton P/N SM500H1/SM1000H1) and record data on appropriate data sheets.

6.3.5.16.1 Conduct Insulation Resistance per A50-24885, Para. 5.2.5

6.3.5.16.2 Conduct Dielectric Withstanding Voltage per A50-24885, Para. 5.3.5

6.3.5.16.3 Conduct Contact Resistance per A50-24885, Para. 5.8.5

6.3.5.17 Disconnect all test equipment, low temperature operation is complete.

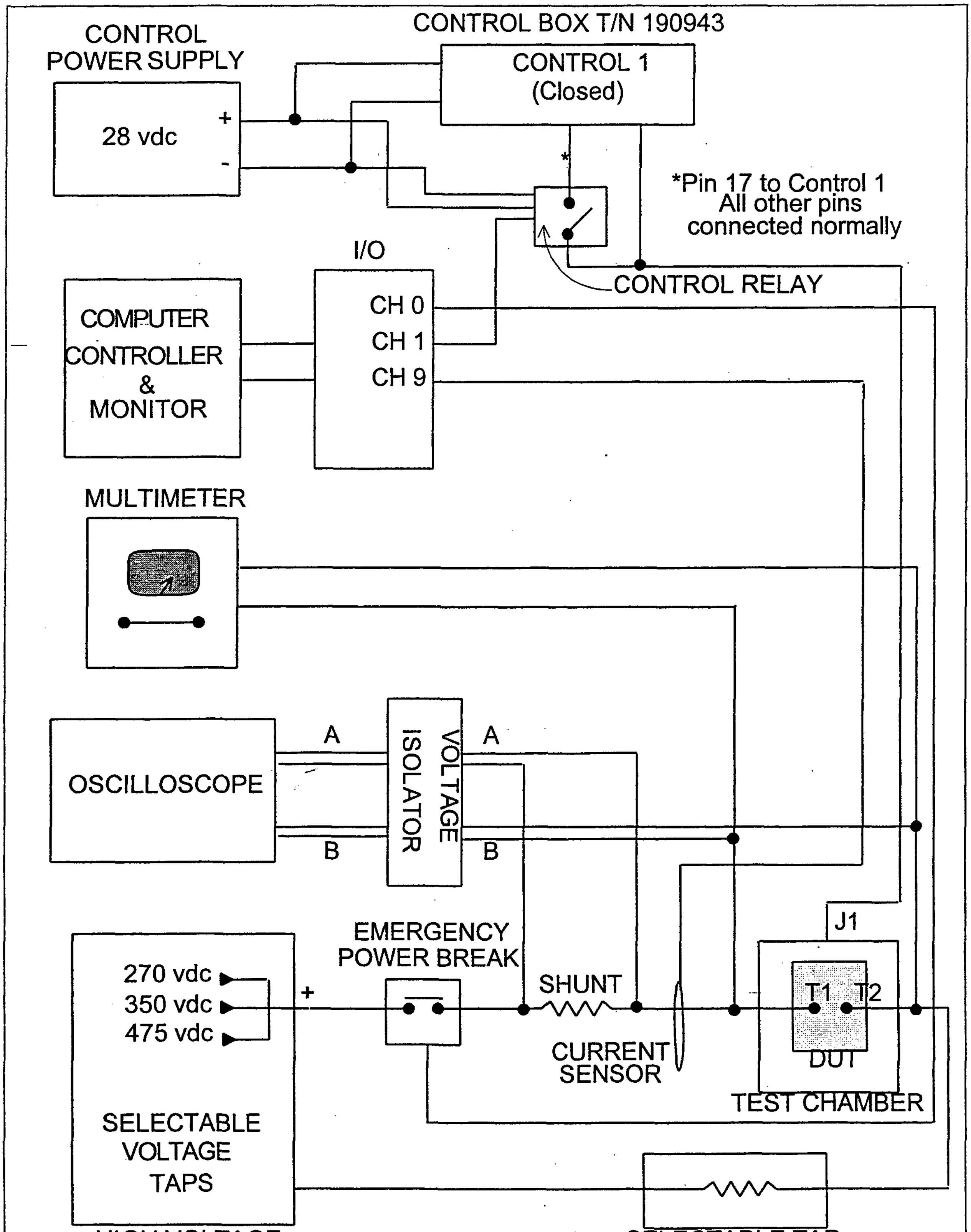


FIGURE 6.3-1
Low Temperature, Test Setup

6.4 THERMAL SHOCK:

6.4.1 Purpose: This test is conducted to verify the mechanical integrity of the contactor when exposed to sudden changes in temperature.

6.4.2 Test Equipment:

- Test Chamber with temperature stabilized at -55 degrees Celsius.
- Test Chamber with temperature stabilized at +71 degrees Celsius.
- Mounting fixture for contactor. Fixture prevents direct contact of the contactor to the internal surfaces of the test chambers and provides for the uniform circulation of chamber air around the unit under test.

6.4.3 Power Requirements:

- Operating power for high and low temperature test chambers (110VAC / 220VAC).

6.4.4 General Requirements:

6.4.4.1 Verify test equipment is within calibration cycle.

6.4.4.2 Eaton standard laboratory data sheets shall be used for this test except for tests noted in Paragraphs 6.4.5.5 through 6.4.5.7.

6.4.5 Test Procedure: The following procedure shall be executed in sequence. Testing shall be conducted in accordance with MIL-STD-202, Method 107, Test Condition B for temperatures of -55 degrees Celsius to +71 degrees Celsius. Reference Figure 6.4-1 for equipment setup graphic.

6.4.5.1 Conduct test per MIL-STD-202, Method 107, Test Condition B for the temperatures noted.

6.4.5.2 Visually examine the contactor for breaking, cracking, chipping, or flaking of the finish.

6.4.5.3 Visually examine the contactor for loosening of the terminals and connector.

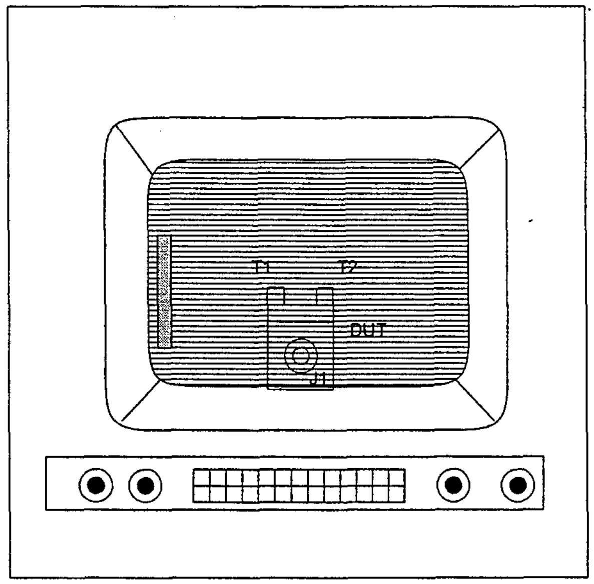
6.4.5.4 Visually examine the contactor's insulating ceramics for signs of cracking or flaking of the insulating material.

6.4.5.5 Conduct the Insulation Resistance Test per A50-24885, Para. 5.2.5.

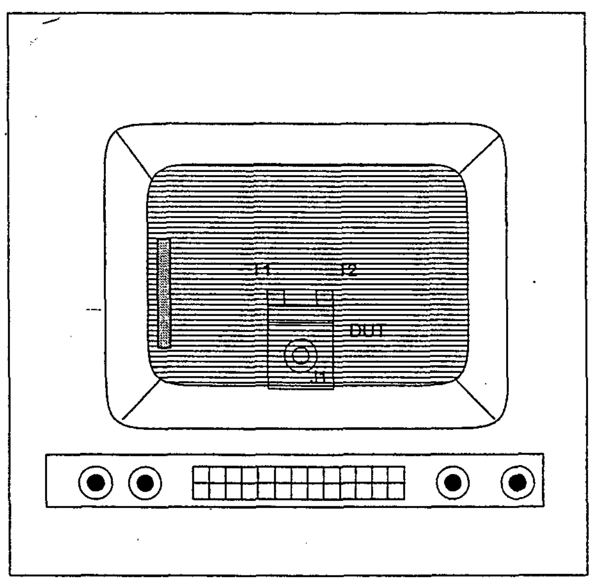
6.4.5.6 Conduct the Dielectric Withstanding Voltage Test per A50-24885, Para. 5.3.5.

6.4.5.7 Conduct the Contact Resistance Test per A50-24885, Para. 5.8.5.

TEMPERATURE CHAMBER @ -55°C



TEMPERATURE CHAMBER @ +71° C



FIQURE 6.4-1

Thermal Shock, Test Setup

6.5 STRENGTH OF TERMINALS:

6.5.1 Purpose: To determine that the terminal design of the contactor meets the terminal strength requirements of MIL-R-6106J.

6.5.2 Test Equipment:

- Test Chamber capable of maintaining a temperature of 150 degrees Celsius.
- Torque wrench capable of reading 150 pound-inches.
- Pull force device capable of reading a force of 100 pounds.
- Mounting fixture for securing contactor during test.

6.5.3 Power Requirements:

- Operating power for high temperature test chamber (110VAC / 220VAC).

6.5.4 General Requirements:

6.5.4.1 Test shall be performed at prevailing factory or laboratory ambient conditions.

6.5.4.2 Verify test equipment is within calibration cycle.

6.5.4.3 Eaton standard laboratory data sheets shall be used for this test except for tests noted in paragraphs 6.5.5.8 through 6.5.5.10.

6.5.5 Test Procedure: The following procedure shall be executed in sequence. Reference Figure 6.5-1 for equipment setup graphic.

6.5.5.1 Mount contactor to mounting fixture via its normal mounting means.

6.5.5.2 Place mounted contactor into room temperature chamber. Set chamber temperature to 150 degrees Celsius. Turn-on chamber.

6.5.5.3 After the unit under test has stabilized at temperature for a minimum of two hours, remove test unit from temperature chamber. Secure mounting fixture to test bench so that device under test is held securely in place. All testing is to be performed within 15 minutes after removal of device from temperature chamber.

6.5.5.4 Apply a 100 pound force to each terminal of the contactor. This force shall be applied coaxial with the threaded terminal in a direction away from the contactor body.

This force shall be applied to the threaded terminals in approximately the same plane as the seat for the terminal lug. Force shall be maintained for a period of one minute.

6.5.5.5 Apply a 100 pound force to each terminal of the contactor. This force shall be applied normal to the threaded terminal in a direction away from the contactor body. Force shall be maintained for a period of one minute.

6.5.5.6 Apply a torque of 150 pound-inches to the terminal mounting nut with all terminal mounting hardware, including one 2/0 terminal lug, assembled in proper order. The applied torque shall be maintained for a period of one minute. Any loosening or rotation of the threaded terminals is cause for rejection.

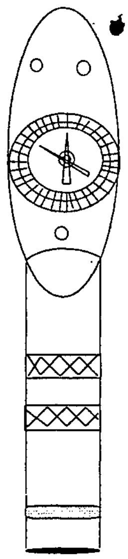
6.5.5.7 Visually examine the ceramic insulators. Any cracking or flaking of these insulators is cause for rejection.

6.5.5.8 Conduct the Insulation Resistance Test per A50-24885, Para. 5.2.5.

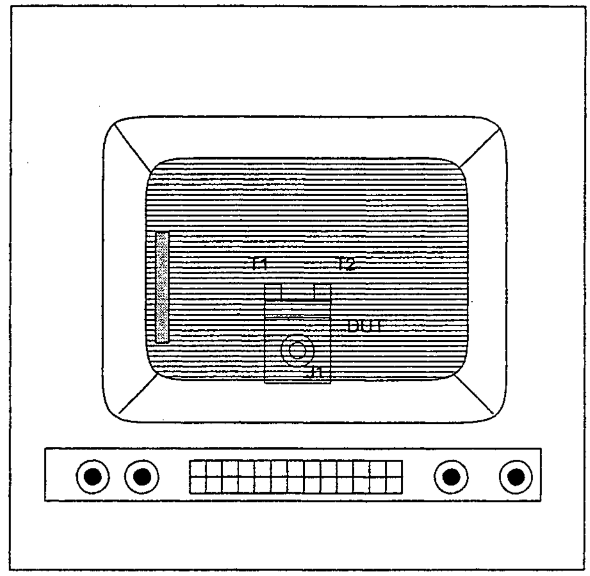
6.5.5.9 Conduct the Dielectric Withstanding Voltage Test per A50-24885, Para. 5.3.5.

6.5.5.10 Conduct the Seal Test per A50-24885, Para. 5.9.5.

TEMPERATURE CHAMBER @ +150° C



TORQUE WRENCH @ 150 lb-in



PULL FORCE DEVICE @ 100 lbs

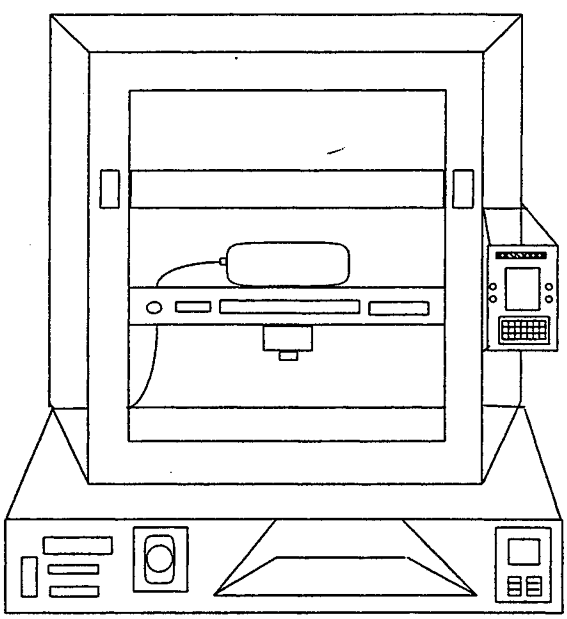


FIGURE 6.5-1
Strength of Terminals, Test Setup

6.6 CONTINUOUS CURRENT (500 AMPERES):

6.6.1 Purpose: To determine that the contactor will perform with no damage such as loosening of terminals or any deterioration of performance beyond the limits specified for the design.

6.6.2 Test Equipment:
- Current Load Panel Eaton TNXXXXXX or equivalent
- DC Power Supply aproximately 270Vdc
- DC Power Supply 28Vdc
- Temperature Chamber Eaton TNXXXXXX or equivalent
- Temperature / Altitude Chamber Eaton TNXXXXXX or equivalent
- Contactor Control Box Eaton P/N 190943
- Thermocouple Temperature Recorder

6.6.3 Power Requirements:
- Line power, 270Vdc, 500 or 1000A (Reference individual contactor requirements)
- Contactor control, 28Vdc
- Equipment power, 110 to 220VAC

6.6.4 General Requirements:

6.6.4.1 Verify test equipment is within calibration cycle.

6.6.4.2 Test Voltage @ 270Vdc.

6.6.4.3 Test Current @ 500 amperes resistive.

6.6.4.4 Test Temperature @ 71 degrees Celsius for S/N 2 & 5.

6.6.4.5 Test Temperature @ 100 degrees Celsius for S/N 1 & 4.

6.6.4.6 Terminal temperature rise shall be monitored during the entire duration of the test. Terminal temperature rise shall not exceed 75 degrees Celsius above ambient .

6.6.4.7 Test loads and circuits shall conform to MIL-R-6106J, Para. 4.7.26.

6.6.4.8 All testing shall be performed at sea level, except S/N 1 shall be tested at an altitude of 60,000 feet.

6.6.4.9 Eaton standard laboratory data sheets shall be used for this test except for tests noted in paragraph 6.6.5.8.

6.6.5 Test Procedure: The following procedure shall be executed in sequence. Reference Figure 6.6-1 for equipment setup graphic.

6.6.5.1 Power connections to the contactor under test shall be accomplished by applying power through appropriate cabling per MIL-R-6106J table XIII. If necessary 270Vdc may be lowered as long as required test current is provided. Contact Voltage Drop and device heating are dependent only on applied current.

6.6.5.2 Thermocouples shall be fixed to each terminal for monitoring terminal temperature rise during the test. Thermal data logger shall be set to record temperatures once every five minutes.

6.6.5.3 Connect the contactor control box to the contactor at J1. Open the main contacts of the unit under test.

6.6.5.4 Set chamber temperature and start chamber and thermal data logger. When chamber has stabilized at the required temperature, close the main contacts of the contactor, applying the required load to the unit under test.

6.6.5.5 At the end of three hours, with the unit under test still at temperature, ensure that the contactor is functional by opening and re-closing control switch (S2) on the contactor control box.

6.6.5.6 Disconnect all power and allow unit to obtain room ambient temperature.

6.6.5.7 Visually examine the test unit for any damage (Example: loose terminals or cracked ceramics).

6.6.5.8 Conduct performance post-tests according to the Acceptance Test Procedure A50-24885 (Eaton P/N SM500H1/SM1000H1) and record data on appropriate data sheets.
Note: Conduct the Seal Test per A50-24885, Para. 5.9.5 (applicable for S/N 1 only).

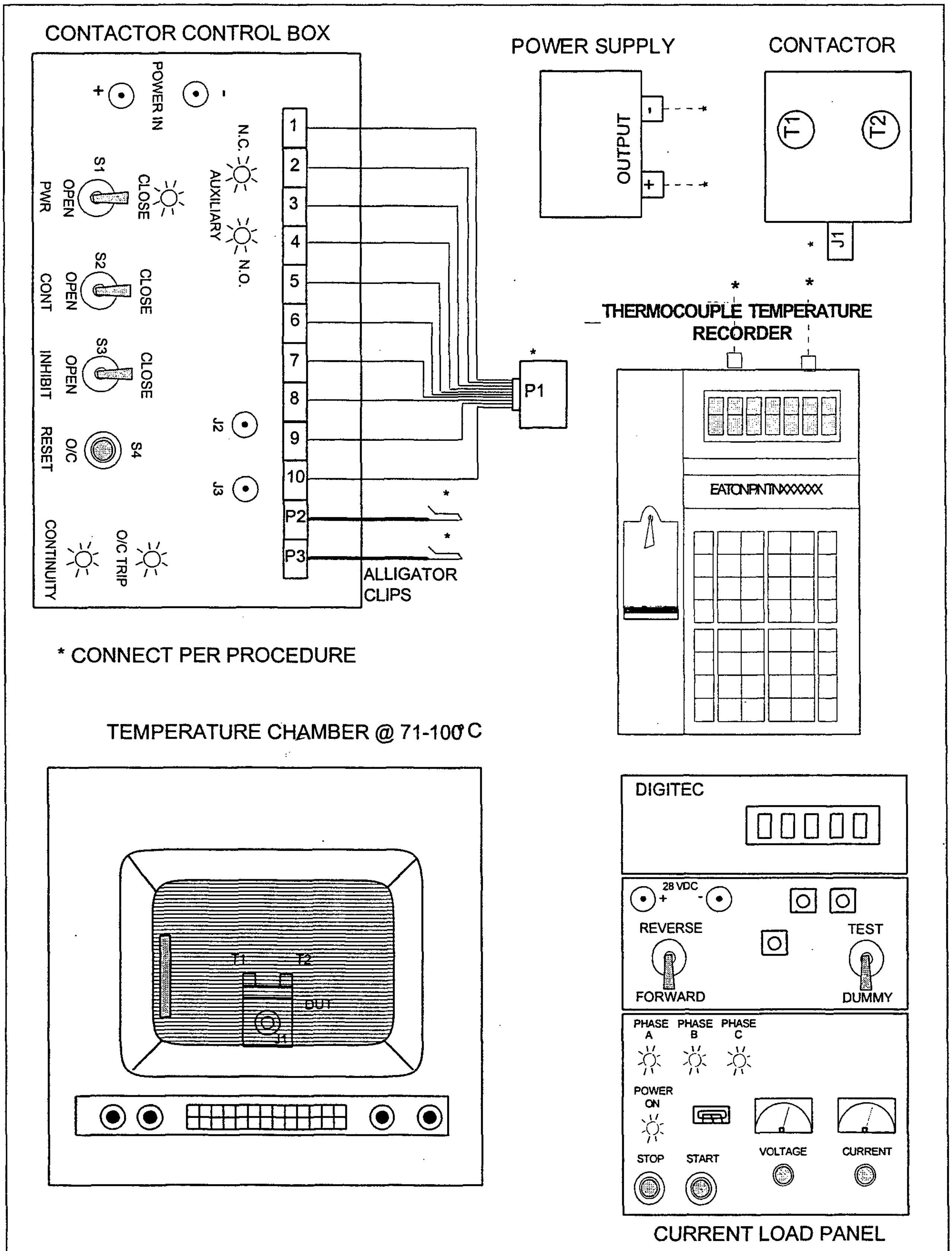


FIGURE 6.6-1
Continuous Current, Test Setup

6.7 CONTINUOUS CURRENT (1000 AMPERES):

6.7.1 Purpose: To determine that the contactor will perform with no damage such as loosening of terminals or any deterioration of performance beyond the limits specified for the design.

6.7.2 Test Equipment:

- Current Load Panel Eaton TNXXXXXX or equivalent
- DC Power Supply 270Vdc
- DC Power Supply 28Vdc
- Temperature Chamber Eaton TNXXXXXX or equivalent
- Temperature / Altitude Chamber Eaton TNXXXXXX or equivalent
- Contactor Control Box Eaton P/N 190943
- Thermocouple Temperature Recorder

6.7.3 Power Requirements:

- Line power approximately, 270Vdc, 500 or 1000A (Reference individual contactor requirements)
- Contactor control, 28Vdc
- Equipment power, 110 to 220 VAC

6.7.4 General Requirements:

6.7.4.1 Verify test equipment is within calibration cycle.

6.7.4.2 Test Voltage @ 270Vdc.

6.7.4.3 Test Current @ 1000 amperes resistive.

6.7.4.4 Test Temperature @ 71 degrees Celsius for S/N 3 & 6.

6.7.4.5 Test Temperature @ 100 degrees Celsius for S/N 1 & 4.

6.7.4.6 Terminal temperature rise shall be monitored during the entire duration of the test. Terminal temperature rise shall not exceed 75 degrees Celsius above ambient.

6.7.4.7 Test loads and circuits shall conform to MIL-R-6106J, Para. 4.7.26.

6.7.4.8 All testing shall be performed at sea level, except S/N 1 shall be tested at an altitude of 60,000 feet.

6.7.4.9 Eaton standard laboratory data sheets shall be used for this test except for tests noted in Paragraph 6.7.5.8.

6.7.5 Test Procedure: The following procedure shall be executed in sequence. Reference Figure 6.7-1 for equipment setup graphic.

6.7.5.1 Power connections to the contactor under test shall be accomplished by applying power through appropriate cabling per MIL-R-6106J table XIII. If necessary 270Vdc may be lowered as long as required test current is provided. Contact Voltage Drop and device heating are dependent only on applied current.

6.7.5.2 Thermocouples shall be fixed to each terminal for monitoring terminal temperature rise during the test. Thermal data logger shall be set to record temperatures once every five minutes.

6.7.5.3 Connect the contactor control box to the contactor at J1. Open the main contacts of the unit under test.

6.7.5.4 Set chamber temperature and start chamber and thermal data logger. When chamber has stabilized at the required temperature, close the main contacts of the contactor, applying the required load to the unit under test.

6.7.5.5 At the end of three hours, with the unit under test still at temperature, ensure that the contactor is functional by opening and re-closing control switch (S2) on the contactor control box.

6.7.5.6 Disconnect all power and allow unit to obtain room ambient temperature.

6.7.5.7 Visually examine the test unit for any damage (Example: loose terminals or cracked ceramics).

6.7.5.8 Conduct performance post-tests according to the Acceptance Test Procedure A50-24885 (Eaton P/N SM500H1/SM1000H1) and record data on appropriate data sheets.
Note: Conduct the Seal Test per A50-24885, Para. 5.9.5 (applicable for S/N 1 only).

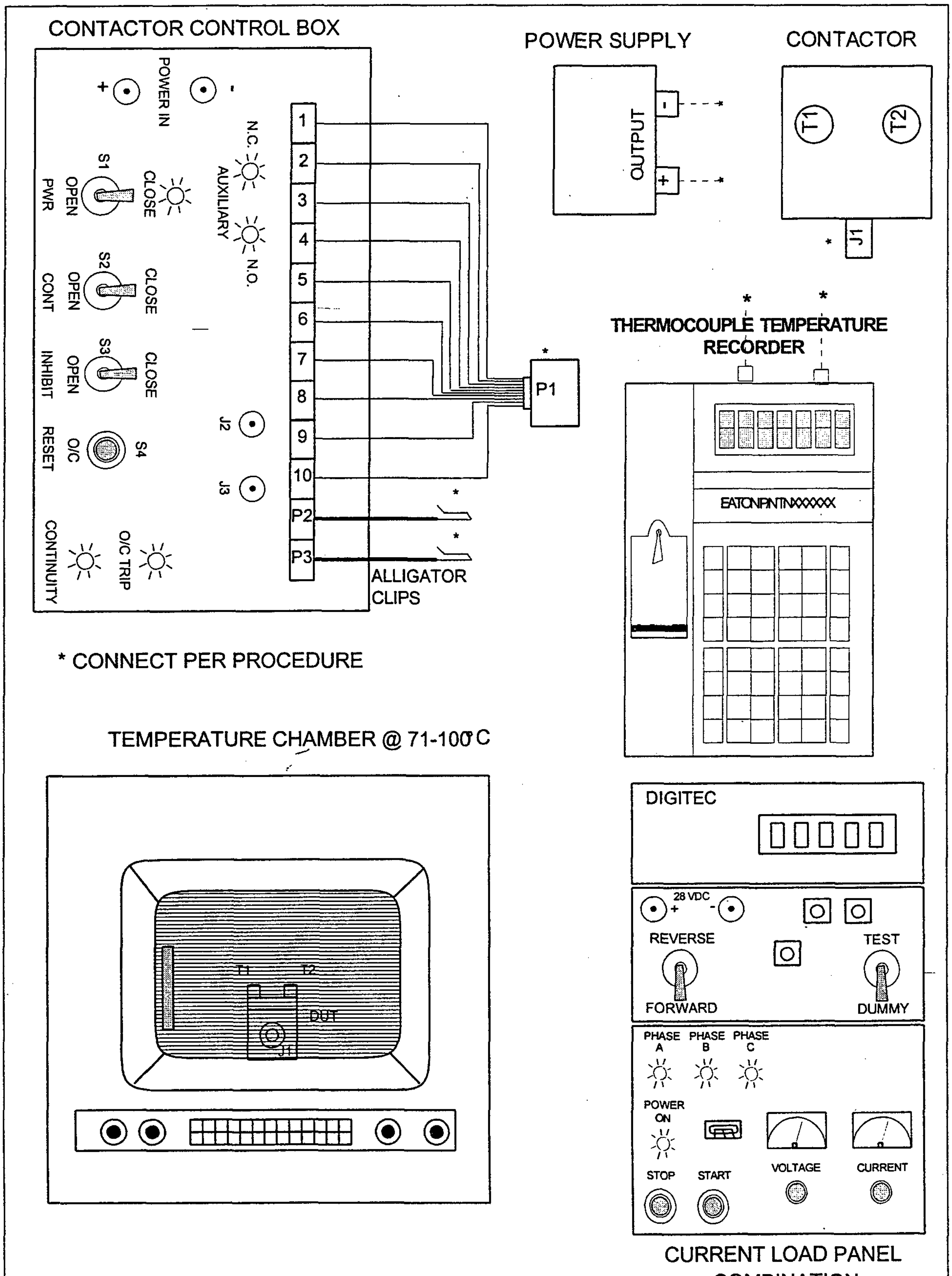


FIGURE 6.7-1
Continuous Current, Test Setup

6.8 SHOCK:

6.8.1 Purpose: To verify proper operation of the contactor design when subjected to implied shock. This test involves the application of two levels of shock (Operating and Non-operating).

6.8.2 Test Equipment:

- DC Power Supply 28Vdc
- Chatter Monitor Eaton P/N TNXXXXXX
- Shock Apparatus Eaton P/N TNXXXXXX
- High Voltage Power Supply/Load Panel Eaton P/N TNXXXXXX
- Contactor Control Box Eaton P/N 190943
- Multimeter Fluke 8840A or equivalent

6.8.3 Power Requirements:

- Equipment power, 110Vdc
- Contactor control, 28Vdc
- Line power, 270VAC 100A
- Auxiliary power, 28Vdc 100mA

6.8.4 General Requirements:

6.8.4.1 Test shall be performed at prevailing factory or laboratory ambient conditions.

6.8.4.2 Verify test equipment is within calibration cycle.

6.8.4.3 Test equipment to be turned on for approximately thirty minutes warm up time.

6.8.4.4 Operating Shock:

6.8.4.4.1 10 g's, 1/2 Sine. Four shocks shall be applied in each direction along each of three mutually perpendicular body axes. In each direction there shall be two pulses with the contacts closed and two pulses with the contacts open (a total of 12 shock pulses). Main contact open circuit voltage will be 270Vdc and current at load panel will be 100A. Auxiliary open circuit voltage will be 28Vdc and auxiliary current will be 100mA.

6.8.4.4.2 Permissible contact opening shall not exceed 2 milliseconds. Contactor must remain in its latched position without applying power to the coil.

6.8.4.4.3 Permissible contact closing shall not exceed 1 microsecond. Contactor must remain in its latched position without applying power to the coil.

6.8.4.4.4 Tests shall be conducted in accordance with MIL-STD-202, Method 213.

6.8.4.4.5 Measurements shall be conducted in accordance with MIL-STD-202, Method 310, Test Circuit B, Test Condition A.

6.8.4.5 Non-Operating Shock:

6.8.4.5.1 100 g's, 1/2 Sine. Four shocks shall be applied along each of three mutually perpendicular body axes. There shall be two pulses with the contacts closed and two pulses with the contacts open (a total of 12 shock pulses).

6.8.4.5.2 Tests shall be conducted in accordance with MIL-STD-202, Method 213.

6.8.5 Test Procedure: The following procedure shall be executed in sequence. Reference Figure 6.9-1 for equipment setup graphic.

6.8.5.1 Operating Shock:

6.8.5.1.1 Setup contactor control box and power supply as follows:
- Connect P1 of contactor control box to J1 on contactor.
- Connect P17 of contactor control box across control relay terminals.
- Connect negative (-) lead of power supply to negative (-) POWER IN terminal on contactor control box.
- Connect positive (+) lead of power supply to positive (+) POWER IN terminal on contactor control box.

6.8.5.1.2 Turn-on power supply and set voltage to 28Vdc.

6.8.5.1.3 Turn on high voltage power supply and set to 270Vdc.

6.8.5.1.4 Set PWR switch (S1) on contactor control box to CLOSE.

6.8.5.1.5 Set CONT 1 switch (S2) to CLOSE position.

6.8.5.1.6 Mount the unit under test into the shock apparatus with the load distributed uniformly on the test platform.

6.8.5.1.7 Setup chatter monitor as follows:
- Connect sensor #1 lead of chatter monitor to T1 of contactor.
- Connect sensor #2 lead of chatter monitor to T2 of contactor.
- Connect sensor #3 lead of chatter monitor to auxiliary Pin 9 of contactor.
- Connect sensor #4 lead of chatter monitor to auxiliary Pin 10 of contactor.

•Set chatter monitor to monitor any break in contacts greater than two (2) milliseconds.
•Set chatter monitor to monitor any make in contacts greater than one (1) microsecond.

6.8.5.1.8 Initiate computer test sequence and set shock level to 10g's @ 1/2 sine (Computer will start shock apparatus).

6.8.5.1.9 Two pulses shall be applied, with the unit under test in latched position, across the three mutually perpendicular body axes.

6.8.5.1.10 Two pulses shall be applied, with the unit under test in the reset position, across the three mutually perpendicular body axes, with no coil current being applied during these pulses.

6.8.5.1.11 Measure contacts per method 310 of MIL-STD-202, test circuit B test condition A (open contacts shall be wired in parallel and closed contacts may be connected in series).

6.8.5.1.12 Disconnect test equipment.

6.8.5.1.13 Conduct performance post-tests according to the Acceptance Test Procedure A50-24885 (Eaton P/N SM500H1/SM1000H1) and record data on appropriate data sheets.

6.8.5.2 Non-Operating Shock:

6.8.5.2.1 Setup contactor control box and power supply as follows:
•Connect P1 of contactor control box to J1 on contactor.
•Connect P17 of contactor control box across control relay terminals.
•Connect negative (-) lead of power supply to negative (-) POWER IN terminal on contactor control box.
•Connect positive (+) lead of power supply to positive (+) POWER IN terminal on contactor control box.

6.8.5.2.2 Turn-on power supply and set voltage to 28Vdc.

6.8.5.2.3 Set PWR switch (S1) on contactor control box to CLOSE.

6.8.5.2.4 Set CONT 1 switch (S2) to CLOSE position.

6.8.5.2.5 Mount unit under test into the shock apparatus with the load distributed uniformly on the test platform.

6.8.5.2.6 Initiate computer test sequence and set shock level to 100g's @ 1/2 sine and duration of test cycle to 15 minutes continuous (Computer will start shock apparatus).

6.8.5.2.7 Two pulses shall be applied, with the unit under test in latched position, across the three mutually perpendicular body axes.

6.8.5.2.8 Two pulses shall be applied, with the unit under test in the reset position, across the three mutually perpendicular body axes, with no coil current being applied during these pulses.

6.8.5.2.9 Disconnect test equipment.

6.8.5.2.10 Conduct performance post-tests according to the Acceptance Test Procedure A50-24885 (Eaton P/N SM500H1/SM1000H1) and record data on appropriate data sheets.

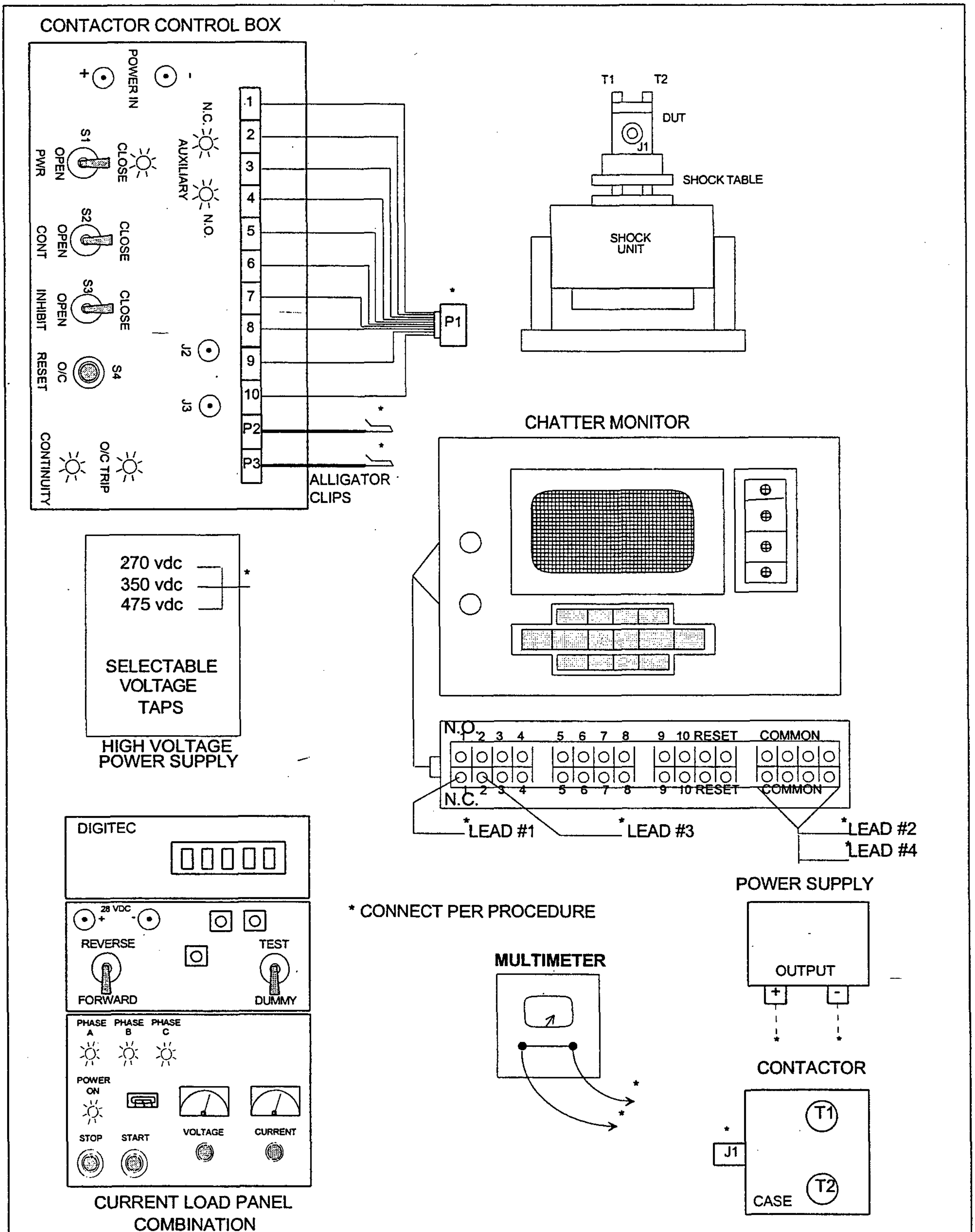


FIGURE 6.8-1
Shock, Test Setup

6.9 VIBRATION:

6.9.1 Purpose: These measurements are made to determine the effect on component parts and contact continuity when exposed to vibration in the frequency ranges and power levels as
specified in F33615-93-C-2359 Table III.

6.9.2 Test Equipment:
- DC Power Supply 28Vdc
- Vibration Apparatus Eaton P/N TNXXXXXX
- Contact Monitor Eaton P/N TNXXXXXX
- High Voltage Power Supply/Load Panel Eaton P/N TNXXXXXX
- Contactor Control Box Eaton P/N 190943
- Multimeter Fluke 8840A or equivalent

6.9.3 Power Requirements:
- Line power, 270Vdc, 500 or 1000A (Reference individual contactor requirements)
- Contactor control, 28Vdc
- Auxiliary power, 28Vdc, 100mA

6.9.4 General Requirements:

6.9.4.1 Test shall be performed at prevailing factory or laboratory ambient conditions.

6.9.4.2 Verify test equipment is within calibration cycle.

6.9.4.3 Test equipment to be turned on for approximately thirty minutes warm up time.

6.9.4.4 Vibration shall occur in each direction along each of three mutually perpendicular body axes. There shall be one operation with the contacts closed and one operation with the contacts open. Main contact open circuit voltage will be 270Vdc and the current at load panel will be 100A. Auxiliary open circuit voltage will be 28Vdc and auxiliary current will be 100mA.

6.9.4.5 Permissible contact opening shall not exceed 2 milliseconds. Contactor must remain in its latched position without applying power to the coil.

6.9.4.6 Permissible contact closing shall not exceed 1 microsecond. Contactor must remain in its latched position without applying power to the coil.

6.9.4.7 Tests shall be conducted in accordance with MIL-STD-202, Method 214, and power spectral density per F33615-93-C-2359 Table III .

6.9.4.8 Measurements shall be conducted in accordance with MIL-STD-202, Method 310, Test Circuit B, Test Condition A.

6.9.5 <u>Test Procedure:</u> The following procedure shall be executed in sequence. Reference Figure 6.9-1 for equipment setup graphic.

6.9.5.1 Setup contactor control box and power supply as follows:
- Connect P1 of contactor control box to J1 on contactor.
- Connect P17 of contactor control box across control relay terminals.
- Connect negative (-) lead of power supply to negative (-) POWER IN terminal on contactor control box.
- Connect positive (+) lead of power supply to positive (+) POWER IN terminal on contactor control box.

6.9.5.2 Turn-on power supply and set voltage to 28Vdc.

6.9.5.3 Turn-on high voltage power supply and set to 270 Vdc.

6.9.5.3 Set PWR switch (S1) on contactor control box to CLOSE.

6.9.5.5 Set CONT 1 switch (S2) to CLOSE position.

6.9.5.5 Mount the unit under test into the vibration apparatus with the load distributed uniformly on the test platform.

6.9.5.6 Setup contact monitor as follows:
- Connect sensor #1 lead of contact monitor to T1 of contactor.
- Connect sensor #2 lead of contact monitor to T2 of contactor.
- Connect sensor #3 lead of chatter monitor to auxiliary Pin 9 of contactor.
- Connect sensor #4 lead of chatter monitor to auxiliary Pin 10 of contactor.
- Set contact monitor to monitor any break in contacts greater than two (2) milliseconds.
- Set contact monitor to monitor any make in contacts greater than one (1) microsecond.

6.9.5.7 Initiate computer test sequence and set vibration profile per F33615-93-C-2359 Table III (Computer will start vibration apparatus).

6.9.5.8 Conduct vibration, with the unit under test in latched position, across the three mutually perpendicular body axes.

6.9.5.9 Conduct vibration, with the unit under test in reset position, across the three mutually perpendicular body axes.

6.9.5.10 Observe panel for BIT fail. Record results on appropriate data sheet.
Note: If test failed, test may be restarted if 15 minute window has not been lapsed and time remaining in window is equal to or greater than 5 minutes.

6.9.5.11 Turn off control and high voltage power supplies.

6.9.5.12 Disconnect all test equipment, vibration is complete.

6.9.5.13 Conduct performance post-tests according to the Acceptance Test Procedure A50-24885 (Eaton P/N SM500H1/SM1000H1) and record data on appropriate data sheets.

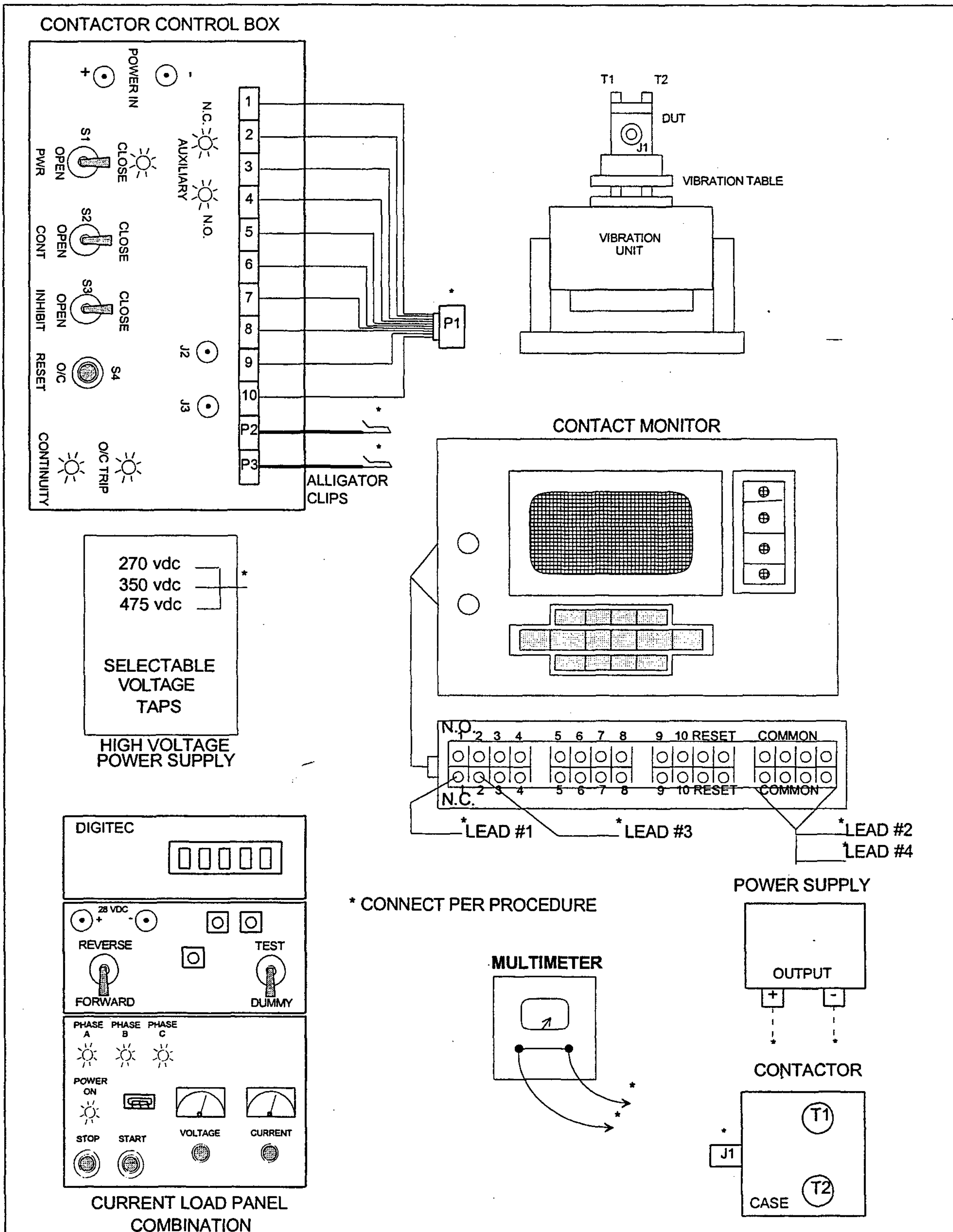


FIGURE 6.9-1
Vibration, Test Setup

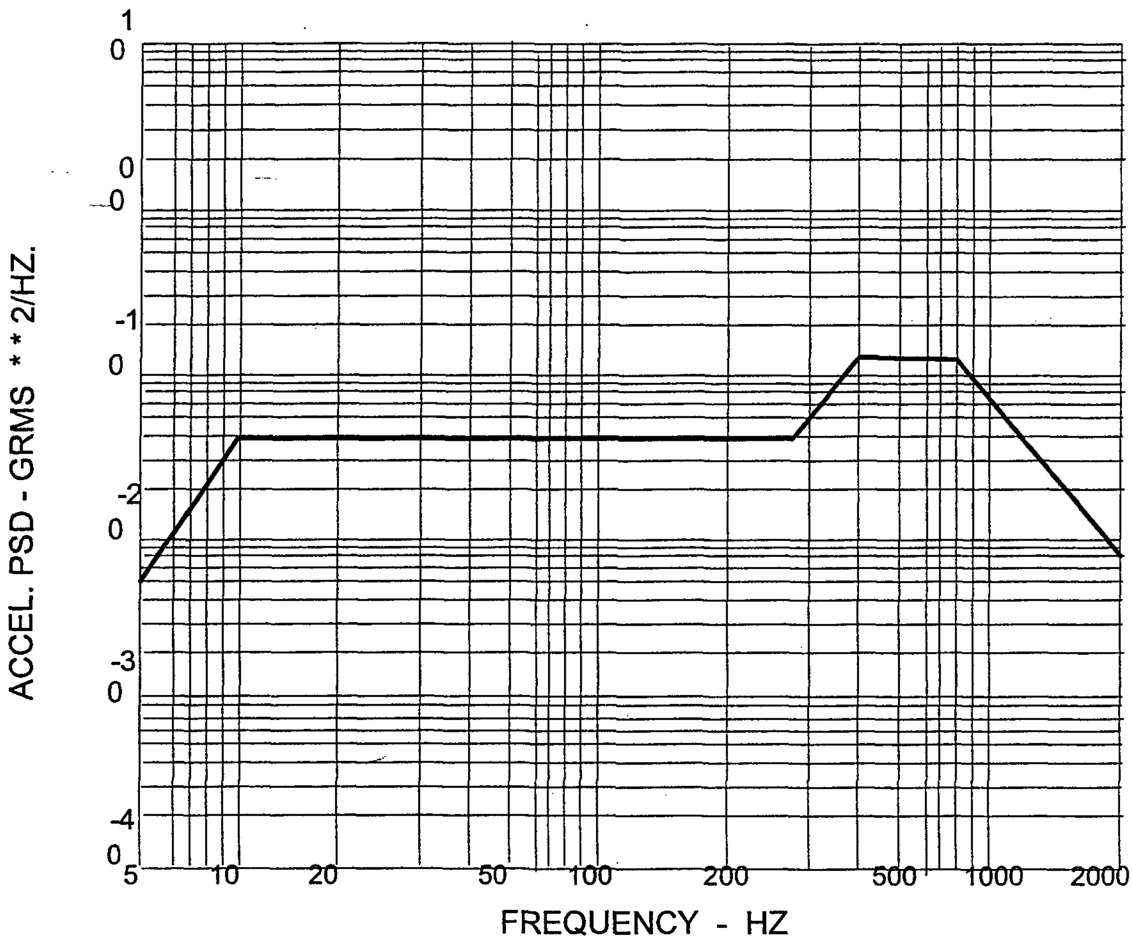


TABLE III - RANDOM VIBRATION TEST LEVELS

___________SCHEDULE A

G RMS OVERALL = 10.79
5.0 - 10.0 HZ 9.0 DB/OCT
10 - 270 HZ 0.40
270 - 400 HZ 9.0 DB/OCT
400 - 800 HZ 0.13
800 - 2000 HZ -9.0 DB/OCT

TABLE 6.9-A
VIBRATION TEST LEVELS

6.10 MECHANICAL LIFE:

6.10.1 Purpose: These measurements are made to validate that the mechanical integrity of the device is sufficient to achieve 100,000 miss-free operations at reduced electrical loading.

6.10.2 Test Equipment:
- Contact Monitor Eaton P/N TNXXXXXX
- High Voltage Power Supply/Load Panel Eaton P/N TNXXXXXX
- DC Power Supply (control) Lambda LLS9040 or equivalent
- Contactor Control Box Eaton P/N TN190943
- Computer and input /output card
- Power hookup cables sized for applicable currents (Reference individual contactor requirements)

6.10.3 Power Requirements:
- Line power, 270Vdc, 100 Amperes
- Contactor control, 28Vdc
- Auxiliary power, 28Vdc, 25mA

6.10.4 General Requirements:

6.10.4.1 Test shall be performed at prevailing factory or laboratory ambient conditions.

6.10.4.2 Verify test equipment is within calibration cycle.

6.10.4.3 Test equipment to be turned on for approximately thirty minutes warm up time.

6.10.5 Test Procedure: The following procedure shall be executed in sequence. Reference Figure 6.10-1 for equipment setup graphic.

6.10.5.1 Setup contact monitor as follows:
- Connect sensor #1 lead of contact monitor to T1 of contactor.
- Connect sensor #2 lead of contact monitor to T2 of contactor.
- Connect sensor #3 lead of chatter monitor to auxiliary Pin 9 of contactor.
- Connect sensor #4 lead of chatter monitor to auxiliary Pin 10 of contactor.
- Set contact monitor to monitor any failure to break in contacts.
- Set contact monitor to monitor any failure to make in contacts.

6.10.5.2 Setup contactor control box and power supply as follows:

- Connect P1 of contactor control box to J1 on contactor.
- Connect P17 of contactor control box across control relay terminals.
- Connect negative (-) lead of power supply to negative (-) POWER IN terminal on contactor control box.
- Connect positive (+) lead of power supply to positive (+) POWER IN terminal on contactor control box.

6.10.5.3 Turn-on control power supply and set voltage to 28Vdc.

6.10.5.4 Turn-on high-voltage power supply and set voltage to 270Vdc.

6.10.5.5 Load main contacts to 270Vdc at 100A resistive.

6.10.5.6 Load auxiliary contacts to 28Vdc at 25mA.

6.10.5.7 Set PWR switch (S1) on contactor control box to CLOSE.

6.10.5.8 Set CONT switch (S2) on contactor control box to OPEN. CONTINUITY indicator light on contactor control box should NOT be illuminated.

6.10.5.9 Initiate computer test sequence and set length of the test cycle to 100,000 operations with 1.5 $\pm$ 1 second on time and approximately 1.5 $\pm$ 1 second off time (Computer will start endurance test).

6.10.5.10 Set CONT switch (S2) on contactor control box to CLOSE position.

6.10.5.11 Contact monitor will terminate test sequence if any failure to make or break conditions are evident during 100,000 operations.

6.10.5.12 Disconnect test equipment, mechanical life test is complete.

6.10.5.13 Conduct performance post-tests according to the Acceptance Test Procedure A50-24885 (Eaton P/N SM500H1/SM1000H1) and record data on appropriate data sheets.

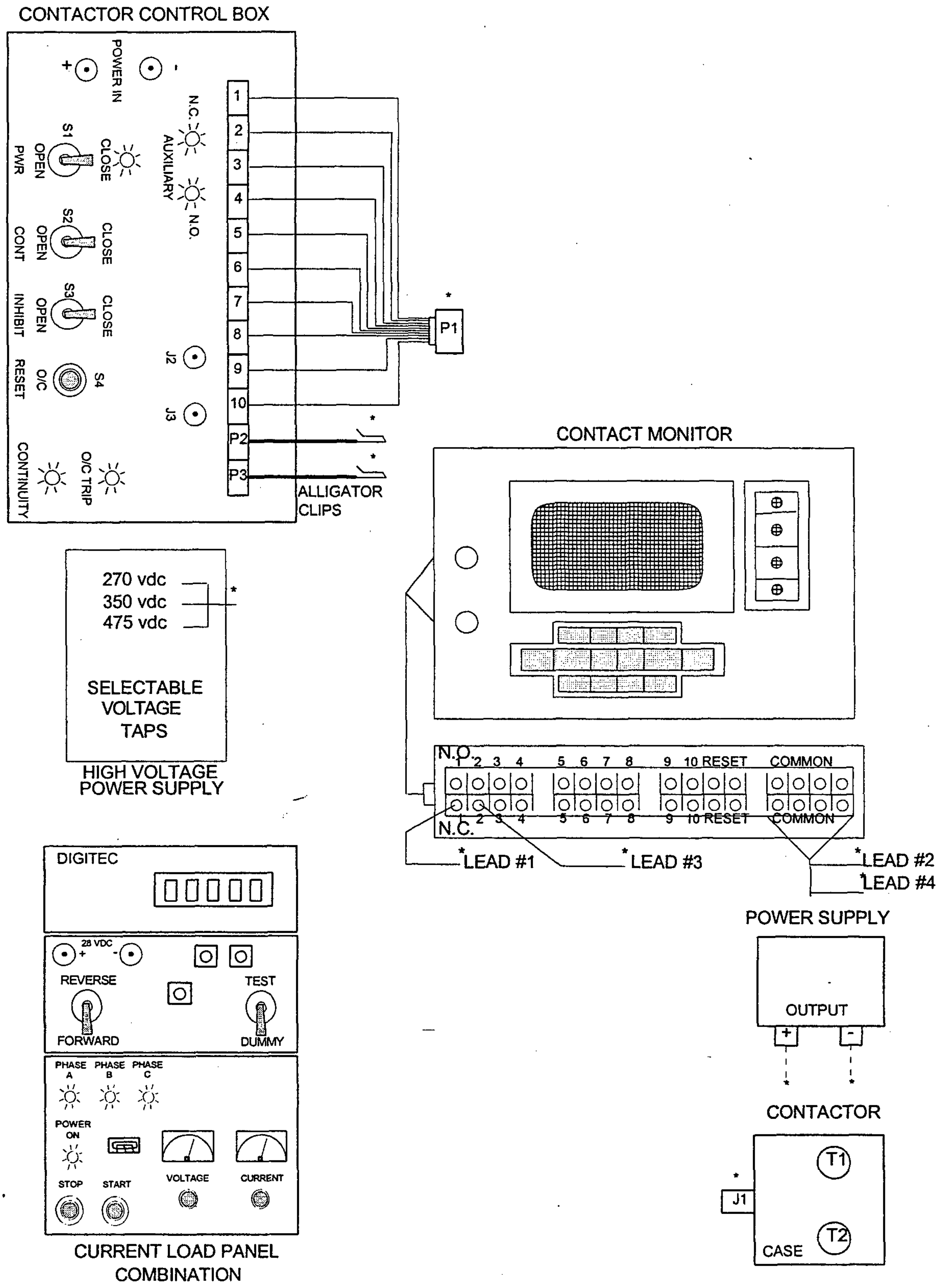


FIGURE 6.10-1
Mechanical Life, Test Setup

6.11 ELECTRICAL LIFE (1000 AMPERE):

6.11.1 Purpose: These measurements are made to verify that the design and construction of the contactor is such that it meets the electrical performance requirements of the specification.

6.11.2 Test Equipment:

- Contact Monitor Eaton P/N TNXXXXXX
- High Voltage Power Supply/Load Panel Eaton P/N TNXXXXXX
- DC Power Supply (control) Lambda LLS9040 or equivalent
- Contactor Control Box Eaton P/N TN190943
- Computer and input /output card
- Power hookup cables sized for applicable currents (Reference individual contactor requirements)

6.11.3 Power Requirements:

- Line power, 270Vdc, 1000A
- Contactor control 28Vdc
- Auxiliary power, 28Vdc, 100mA

6.11.4 General Requirements:

6.11.4.1 Test shall be performed at prevailing factory or laboratory ambient conditions.

6.11.4.2 Verify test equipment is within calibration cycle.

6.11.4.3 Test equipment to be turned on for approximately thirty minutes warm up time.

6.11.5 Test Procedure: The following procedure shall be executed in sequence. Reference Figure 6.11-1 for equipment setup graphic.

6.11.5.1 Setup contact monitor as follows:

- Connect sensor #1 lead of contact monitor to T1 of contactor.
- Connect sensor #2 lead of contact monitor to T2 of contactor.
- Connect sensor #3 lead of chatter monitor to auxiliary Pin 9 of contactor.
- Connect sensor #4 lead of chatter monitor to auxiliary Pin 10 of contactor.
- Set contact monitor to monitor any failure to break in contacts.
- Set contact monitor to monitor any failure to make in contacts.

6.11.5.2 Setup contactor control box and power supply as follows:

- Connect P1 of contactor control box to J1 on contactor.
- Connect P17 of contactor control box across control relay terminals.
- Connect negative (-) lead of power supply to negative (-) POWER IN terminal on contactor control box.
- Connect positive (+) lead of power supply to positive (+) POWER IN terminal on contactor control box.

6.11.5.3 Turn-on control power supply and set voltage to 28Vdc.

6.11.5.4 Turn-on high-voltage power supply and set voltage to 270Vdc.

6.11.5.5 Load main contacts to 270Vdc at 1000A, and 3ms L/R time constant.

6.11.5.6 Load auxiliary contacts to 28Vdc at 100mA.

6.11.5.7 Set PWR switch (S1) on contactor control box to CLOSE.

6.11.5.8 Set CONT switch (S2) on contactor control box to OPEN. CONTINUITY indicator light on contactor control box should NOT be illuminated.

6.11.5.9 Initiate computer test sequence and set length of the test cycle to 500 operations with 1.5 ± 1 second on time and approximately 1.5 ± 1 second off time (Computer will start endurance test).

6.11.5.10 Set CONT switch (S2) on contactor control box to CLOSE position.

6.11.5.11 Contact monitor will terminate test sequence if any failure to make or break conditions are evident during 500 operations.

6.11.5.12 Disconnect test equipment.

6.11.5.13 Conduct performance post-tests according to the Acceptance Test Procedure A50-24885 (Eaton P/N SM500H1/SM1000H1) and record data on appropriate data sheets. If unit passes all requirements proceed to 6.11.5.14.

6.11.5.14 Repeat 6.11.5.1 through 6.11.5.13 until device fails to make or break test current, device fails ATP post-test, or device achieves 5,000 operations. Record all data on appropriate data sheets. If device achieves 5,000 operations and passes all ATP post-test requirements proceed to 6.11.5.15.

6.11.5.15 Initiate computer test sequence and continue test with 1.5 ± 1 second on time and approximately 1.5 ± 1 second off time until device fails to make or break test current.

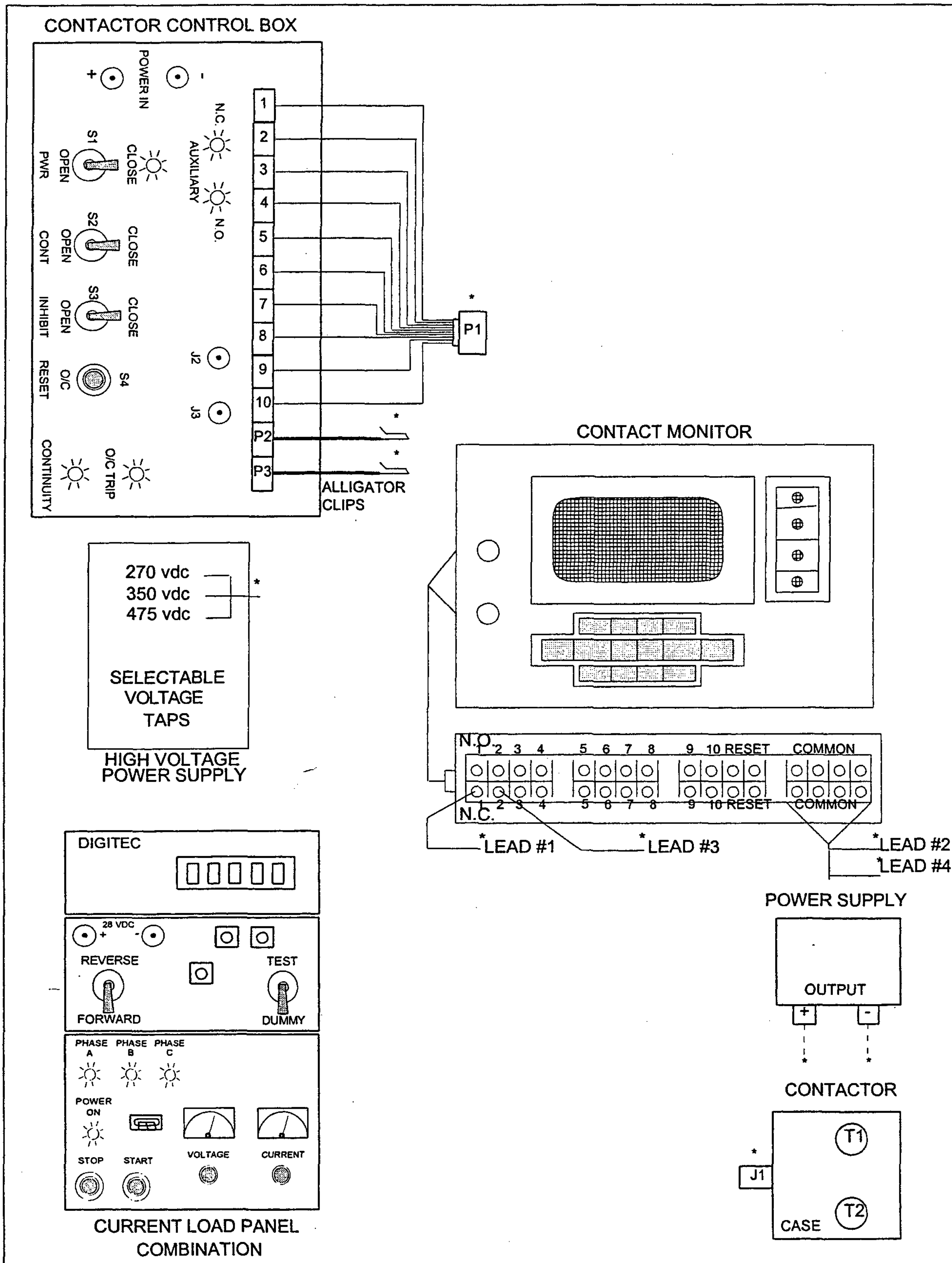


FIGURE 6.11-1
Electrical Life, Test Setup

6.12 ELECTRICAL LIFE (500 AMPERE):

6.12.1 Purpose: These measurements are made to verify that the design and construction of the contactor is such that it meets the electrical performance requirements of the specification.

6.12.2 Test Equipment:

- Contact Monitor Eaton P/N TNXXXXXX
- High Voltage Power Supply/Load Panel Eaton P/N TNXXXXXX
- DC Power Supply (control) Lambda LLS9040 or equivalent
- Contactor Control Box Eaton P/N TN190943
- Computer and input /output card
- Power hookup cables sized for applicable currents (Reference individual contactor requirements)

6.12.3 Power Requirements:

- Line power, 270Vdc, 500 Amperes
- Contactor control, 28Vdc
- Auxiliary power, 28Vdc, 100mA

6.12.4 General Requirements:

6.12.4.1 Test shall be performed at prevailing factory or laboratory ambient conditions.

6.12.4.2 Verify test equipment is within calibration cycle.

6.12.4.3 Test equipment to be turned on for approximately thirty minutes warm up time.

6.12.5 Test Procedure: The following procedure shall be executed in sequence. Reference Figure 6.12-1 for equipment setup graphic.

6.12.5.1 Setup contact monitor as follows:

- Connect sensor #1 lead of contact monitor to T1 of contactor.
- Connect sensor #2 lead of contact monitor to T2 of contactor.
- Connect sensor #3 lead of chatter monitor to auxiliary Pin 9 of contactor.
- Connect sensor #4 lead of chatter monitor to auxiliary Pin 10 of contactor.
- Set contact monitor to monitor any failure to break in contacts.
- Set contact monitor to monitor any failure to make in contacts.

6.12.5.2 Setup contactor control box and power supply as follows:

- Connect P1 of contactor control box to J1 on contactor.
- Connect P17 of contactor control box across control relay terminals.
- Connect negative (-) lead of power supply to negative (-) POWER IN terminal on contactor control box.
- Connect positive (+) lead of power supply to positive (+) POWER IN terminal on contactor control box.

6.12.5.3 Turn-on control power supply and set voltage to 28Vdc.

6.12.5.4 Turn-on high-voltage power supply and set voltage to 270Vdc.

6.12.5.5 Load main contacts to 270Vdc at 500A, 3ms L/R time constant.

6.12.5.6 Load auxiliary contacts to 28Vdc at 100mA.

6.12.5.7 Set PWR switch (S1) on contactor control box to CLOSE.

6.12.5.8 Set CONT switch (S2) on contactor control box to OPEN. CONTINUITY indicator light on contactor control box should NOT be illuminated.

6.12.5.9 Initiate computer test sequence and set length of the test cycle to 5,000 operations with 1.5 ± 1 second on time and approximately 1.5 ± 1 second off time (Computer will start endurance test).

6.12.5.10 Set CONT switch (S2) on contactor control box to CLOSE position.

6.12.5.11 Contact monitor will terminate test sequence if any failure to make or break conditions are evident during 5,000 operations.

6.12.5.12 Disconnect test equipment.

6.12.5.13 Conduct performance post-tests according to the Acceptance Test Procedure A50-24885 (Eaton P/N SM500H1/SM1000H1) and record data on appropriate data sheets. If unit passes all requirements proceed to 6.12.14.

6.12.5.14 Repeat 6.12.5.1 through 6.12.5.13 until device fails to make or break test current, device fails ATP post-test, or device achieves 50,000 operations. Record all data on appropriate data sheets. If device achieves 50,000 operations and passes all ATP post-test requirements proceed to 6.12.5.15.

6.12.5.15 Initiate computer test sequence and continue test with 1.5 ± 1 second on time and approximately 1.5 ± 1 second off time until device fails to make or break test current.

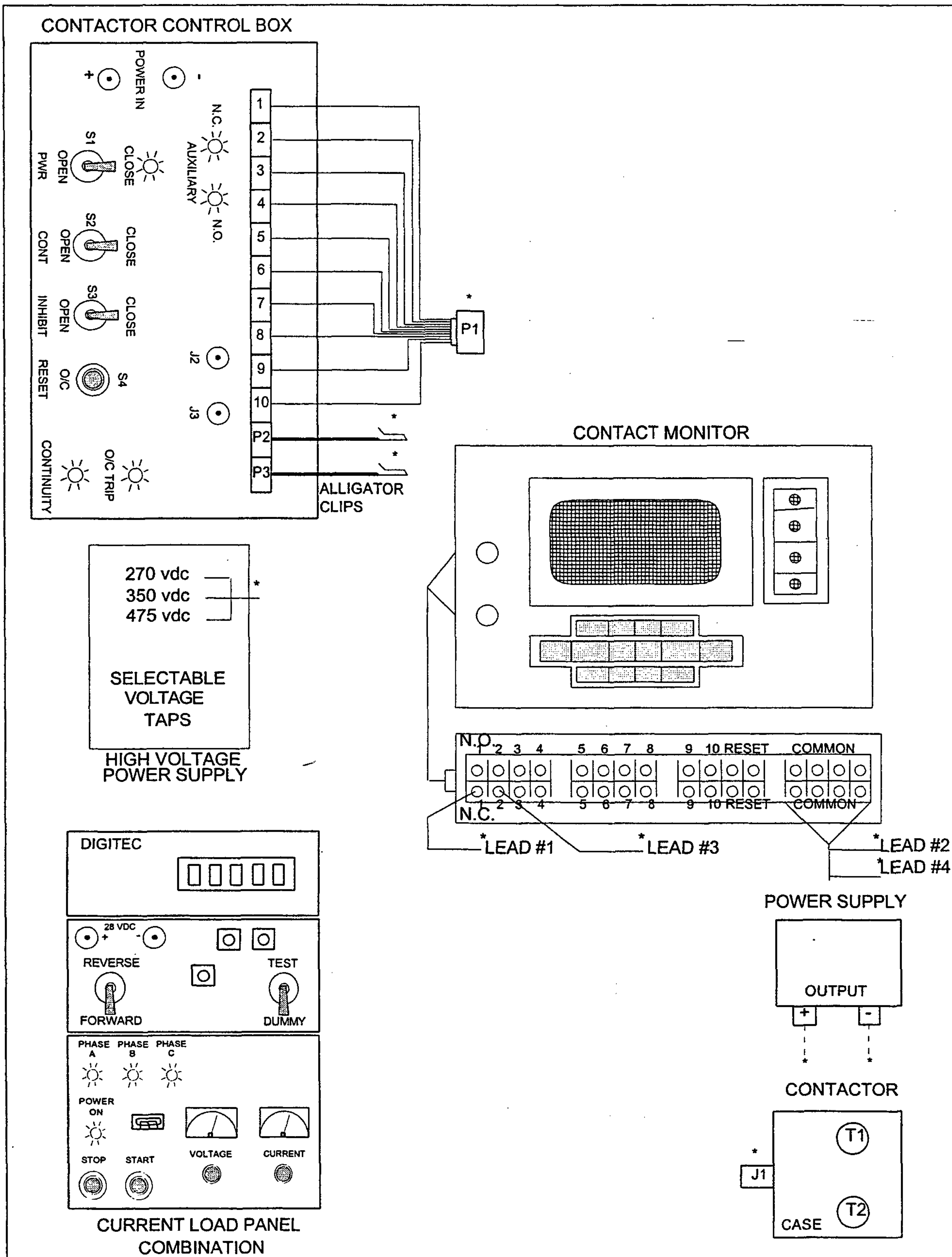


FIGURE 6.12-1
Electrical Life, Test Setup

6.13 RUPTURE:

6.13.1 Purpose: These measurements are made to verify that the contactor has sufficient thermal capability to make and break severe fault currents without catastrophic failure.

6.13.2 Test Equipment:

- Contact Monitor Eaton P/N TNXXXXXX
- Oscilloscope Tektronic Model 5441 or equivalent
- Voltage Isolator Tektronic Model A6902B or equivalent
- High Voltage Power Supply/Load Panel Eaton P/N TNXXXXXX
- Test Chamber Eaton P/N TNXXXXXX
- DC Power Supply (control) Lambda LLS9040 or equivalent
- Contactor Control Box Eaton P/N TN190943
- Computer and input /output card
- Printer / Scope camera for recording scope traces
- Power hookup cables sized for applicable currents (Reference individual contactor requirements)

6.13.3 Power Requirements:

- Line power, 350Vdc, 4500 Amperes
- Contactor control, 28Vdc

6.13.4 General Requirements:

6.13.4.1 Test shall be performed at prevailing factory or laboratory ambient conditions.

6.13.4.2 Verify test equipment is within calibration cycle.

6.13.4.3 Test equipment to be turned on for approximately thirty minutes warm up time.

6.13.5 Test Procedure: The following procedure shall be executed in sequence. Reference Figure 6.13-1 for equipment setup graphic.

6.13.5.1 Setup contact monitor as follows:

- Connect sensor #1 lead of contact monitor to T1 of contactor.
- Connect sensor #2 lead of contact monitor to T2 of contactor.
- Connect sensor #3 lead of chatter monitor to auxiliary Pin 9 of contactor.
- Connect sensor #4 lead of chatter monitor to auxiliary Pin 10 of contactor.
- Set contact monitor to monitor any failure to break in contacts.

•Set contact monitor to monitor any failure to make in contacts.

6.13.5.2 Setup contactor control box and power supply as follows:
- •Connect P1 of contactor control box to J1 on contactor.
- •Connect P17 of contactor control box across control relay terminals.
- •Connect negative (-) lead of power supply to negative (-) POWER IN terminal on contactor control box.
- • Connect positive (+) lead of power supply to positive (+) POWER IN terminal on contactor control box.

6.13.5.3 Setup oscilloscope as follows:
- •Connect channel A on oscilloscope to channel A on voltage isolator. Set channel A on oscilloscope to 100mv/div and channel A on voltage isolator to 20mv:100mv.
- •Connect channel B on oscilloscope to channel B on voltage isolator. Set channel B on oscilloscope to 100mv/div and channel B on voltage isolator to 200v:100mv to expect approximately 140mv deflection.
- •On oscilloscope set controls for memory, time interval, channel B trig at 70mv level rising edge.
- •Connect channel A of the voltage isolator across the appropriate 500A/100mv or 1000A/100mv shunt and channel B of the voltage isolator across the contactor.

6.13.5.3 Turn-on control power supply and set voltage to 28Vdc.

6.13.5.4 Turn-on high-voltage power supply and set voltage to 350Vdc.

6.13.5.5 Load main contacts to 350Vdc at 4500A, 3ms L/R time constant.

6.13.5.7 Set PWR switch (S1) on contactor control box to CLOSE.

6.13.5.8 Set CONT switch (S2) on contactor control box to OPEN. CONTINUITY indicator light on contactor control box should NOT be illuminated.

6.13.5.9 Initiate computer test sequence and set length of the test cycle to 5 cycles with .2 seconds on time and approximately 30 seconds off time (Computer will start rupture test).

6.13.5.10 Set CONT switch (S2) on contactor control box to CLOSE position.

6.13.5.11 Contact monitor will terminate test sequence if any failure to make or break conditions are evident during the five cycles.

6.13.5.12 Read oscilloscope, create and label a hard-copy of the measurement. Labeling should include date of test, DUT identification number, polarity, and operation cycle.

6.13.5.13 Turn off control and high voltage power supplies.

6.13.5.14 Reverse power cables connected to DUT terminals T1 and T2 in order to reverse direction of current flow.

6.13.5.15 Repeat steps 6.13.5.9 through 6.13.5.12 for a total of ten (10) operations (five operations in each direction).

6.13.5.16 Disconnect test equipment.

6.13.5.17 Conduct performance post-tests according to the Acceptance Test Procedure A50-24885 (Eaton P/N SM500H1/SM1000H1) and record data on appropriate data sheets. If unit passes all requirements proceed to 6.13.5.18.

6.13.5.18 Repeat 6.13.5.9 through 6.13.5.17 until device fails to make or break test current, device fails ATP post-test, or device achieves 50 operations in each direction. Record all data on appropriate data sheets.

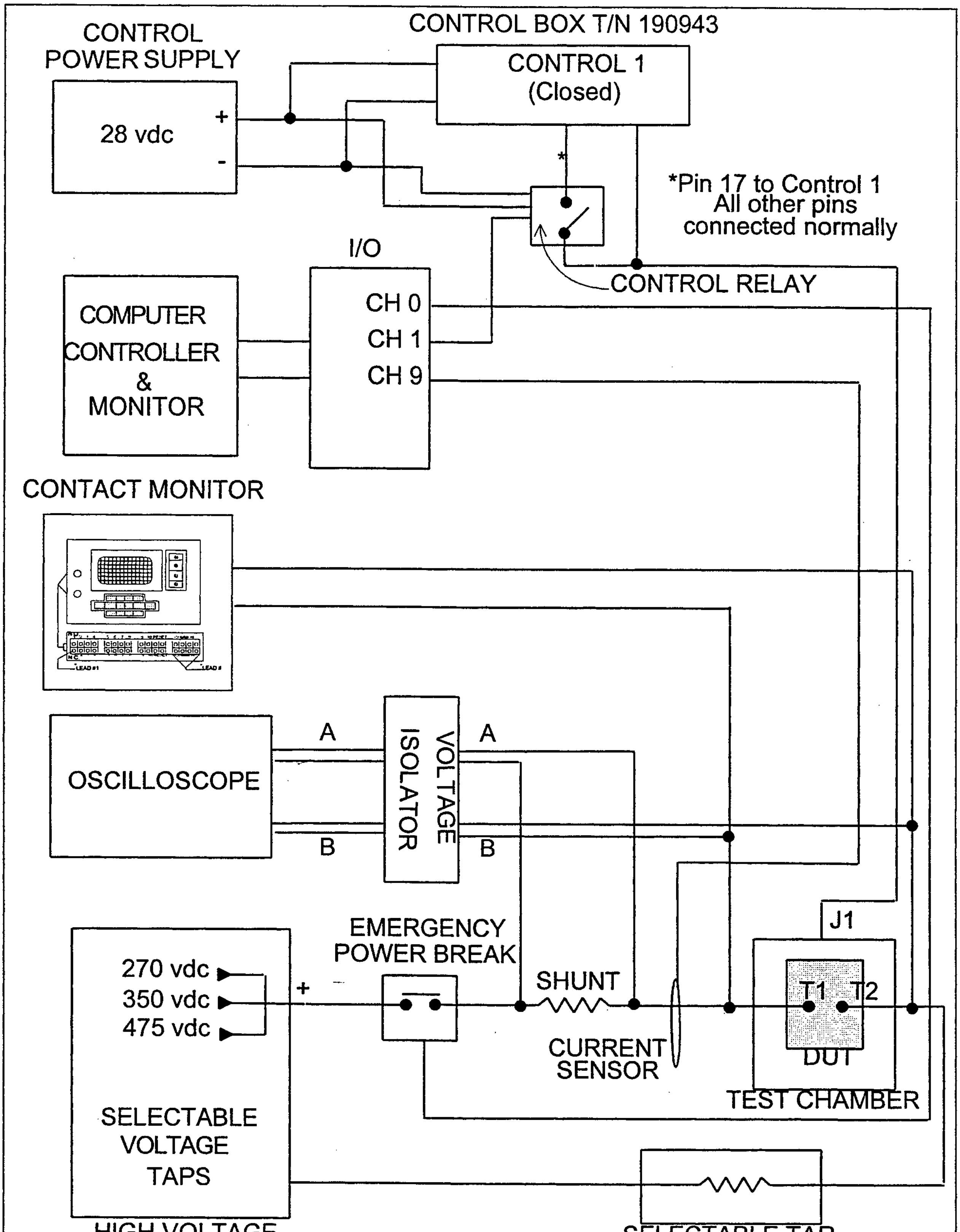


Figure 6.13-1
Rupture, Test Setup

6.14 ELECTRICAL AT ALTITUDE:

6.14.1 Purpose: These measurements are made to verify that the design and construction of the contactor is such that it meets the electrical performance of the specification when tested at the maximum altitude level of 60,000 feet.

6.14.2 Test Equipment:

- Contact Monitor Eaton P/N TNXXXXXX
- Oscilloscope Tektronic Model 5441 or equivalent
- Voltage Isolator Tektronic Model A6902B or equivalent
- High Voltage Power Supply/Load Panel Eaton P/N TNXXXXXX
- Test Chamber Eaton P/N TNXXXXXX
- DC Power Supply (control) Lambda LLS9040 or equivalent
- Contactor Control Box Eaton P/N TN190943
- Computer and input /output card
- Printer / Scope camera for recording scope traces
- Power hookup cables sized for applicable currents (Reference individual contactor requirements)

6.14.3 Power Requirements:

- Line power, 270Vdc, 1000A
- Contactor control , 28Vdc

6.14.4 General Requirements:

6.14.4.1 Test shall be performed at prevailing factory or laboratory ambient conditions.

6.14.4.2 Verify test equipment is within calibration cycle.

6.14.4.3 Test equipment to be turned on for approximately thirty minutes warm up time.

6.14.5 Test Procedure: The following procedure shall be executed in sequence. Reference Figure 6.14-1 for equipment setup graphic.

6.14.5.1 Setup contact monitor as follows:

- Connect sensor #1 lead of contact monitor to T1 of contactor.
- Connect sensor #2 lead of contact monitor to T2 of contactor.
- Connect sensor #3 lead of chatter monitor to auxiliary Pin 9 of contactor.

- Connect sensor #4 lead of chatter monitor to auxiliary Pin 10 of contactor.
- Set contact monitor to monitor any failure to break in contacts.
- Set contact monitor to monitor any failure to make in contacts.

6.14.5.2 Setup contactor control box and power supply as follows:
- Connect P1 of contactor control box to J1 on contactor.
- Connect P17 of contactor control box across control relay terminals.
- Connect negative (-) lead of power supply to negative (-) POWER IN terminal on contactor control box.
- Connect positive (+) lead of power supply to positive (+) POWER IN terminal on contactor control box.

6.14.5.3 Setup oscilloscope as follows:
- Connect channel A on oscilloscope to channel A on voltage isolator. Set channel A on oscilloscope to 100mv/div and channel A on voltage isolator to 20mv:100mv.
- Connect channel B on oscilloscope to channel B on voltage isolator. Set channel B on oscilloscope to 100mv/div and channel B on voltage isolator to 200v:100mv to expect approximately 140mv deflection.
- On oscilloscope set controls for memory, time interval, channel B trig at 70mv level rising edge.
- Connect channel A of the voltage isolator across the appropriate 500A/100mv or 1000A/100mv shunt and channel B of the voltage isolator across the contactor.

6.14.5.4 Turn-on control power supply and set voltage to 28Vdc.

6.14.5.5 Turn-on high-voltage power supply and set voltage to 270Vdc.

6.14.5.6 Load main contacts to 270Vdc at 1000A resistive and 3ms L/R time constant.

6.14.5.7 Set PWR switch (S1) on contactor control box to CLOSE.

6.14.5.8 Set CONT switch (S2) on contactor control box to OPEN. CONTINUITY indicator light on contactor control box should NOT be illuminated.

6.14.5.9 With DUT in test chamber, raise altitude to 60,000 feet

6.14.5.10 Initiate computer test sequence and set length of the test cycle to five (5) operations with 1.5 $\pm$ 1 second on time and approximately 1.5 $\pm$ 1 second off time (Computer will start altitude test).

6.14.5.11 Set CONT switch (S2) on contactor control box to CLOSE position.

•Connect sensor #4 lead of chatter monitor to auxiliary Pin 10 of contactor.
•Set contact monitor to monitor any failure to break in contacts.
•Set contact monitor to monitor any failure to make in contacts.

6.14.5.2 Setup contactor control box and power supply as follows:
•Connect P1 of contactor control box to J1 on contactor.
•Connect P17 of contactor control box across control relay terminals.
•Connect negative (-) lead of power supply to negative (-) POWER IN terminal on contactor control box.
• Connect positive (+) lead of power supply to positive (+) POWER IN terminal on contactor control box.

6.14.5.3 Setup oscilloscope as follows:
•Connect channel A on oscilloscope to channel A on voltage isolator. Set channel A on oscilloscope to 100mv/div and channel A on voltage isolator to 20mv:100mv.
•Connect channel B on oscilloscope to channel B on voltage isolator. Set channel B on oscilloscope to 100mv/div and channel B on voltage isolator to 200v:100mv to expect approximately 140mv deflection.
•On oscilloscope set controls for memory, time interval, channel B trig at 70mv level rising edge.
•Connect channel A of the voltage isolator across the appropriate 500A/100mv or 1000A/100mv shunt and channel B of the voltage isolator across the contactor.

6.14.5.4 Turn-on control power supply and set voltage to 28Vdc.

6.14.5.5 Turn-on high-voltage power supply and set voltage to 270Vdc.

6.14.5.6 Load main contacts to 270Vdc at 1000A resistive and 3ms L/R time constant.

6.14.5.7 Set PWR switch (S1) on contactor control box to CLOSE.

6.14.5.8 Set CONT switch (S2) on contactor control box to OPEN. CONTINUITY indicator light on contactor control box should NOT be illuminated.

6.14.5.9 With DUT in test chamber, raise altitude to 60,000 feet

6.14.5.10 Initiate computer test sequence and set length of the test cycle to five (5) operations with 1.5 $\pm$ 1 second on time and approximately 1.5 $\pm$ 1 second off time (Computer will start altitude test).

6.14.5.11 Set CONT switch (S2) on contactor control box to CLOSE position.

6.14.5.12 Contact monitor will terminate test sequence if any failure to make or break conditions are evident during this operation.

6.14.5.13 Read oscilloscope, create and label a hard-copy of the measurement. Labeling should include date of test, DUT identification number, polarity, and operation cycle.

6.14.5.14 Turn off control and high voltage power supplies.

6.14.5.15 Reverse power cables connected to DUT terminals T1 and T2 in order to reverse direction of current flow.

6.14.5.16 Repeat steps 6.14.5.10 through 6.13.5.14 for a total of ten (10) operations (five operation in each direction).

6.14.5.17 Disconnect test equipment.

6.14.5.18 Conduct performance post-tests according to the Acceptance Test Procedure A50-24885 (Eaton P/N SM1000H1) and record data on appropriate data sheets. If unit passes all requirements proceed to 6.14.5.19.

6.14.5.19 Repeat 6.14.5.1 through 6.14.5.18 until device fails to make or break test current, or device fails ATP post-test. Record all data on appropriate data sheets. If device achieves a total of fifty (50) operations in each direction and passes all ATP post-test requirements proceed to 6.14.5.20.

6.14.5.20 Repeat steps 6.14.5.1 through 6.14.5.9.

6.14.5.21 Initiate computer test sequence and set length of the test cycle to 50,000 operations in one direction only with 1.5 $\pm$ 1 second on time and approximately 1.5 $\pm$ 1 second off time (Computer will start altitude test).

6.14.5.22 Set CONT switch (S2) on contactor control box to CLOSE position.

6.14.5.23 Contact monitor will terminate test sequence if any failure to make or break conditions are evident during this operation.

6.14.5.24 Disconnect test equipment.

6.14.5.25 Conduct performance post-tests according to the Acceptance Test Procedure A50-24885 (Eaton P/N SM1000H1) and record data on appropriate data sheets.

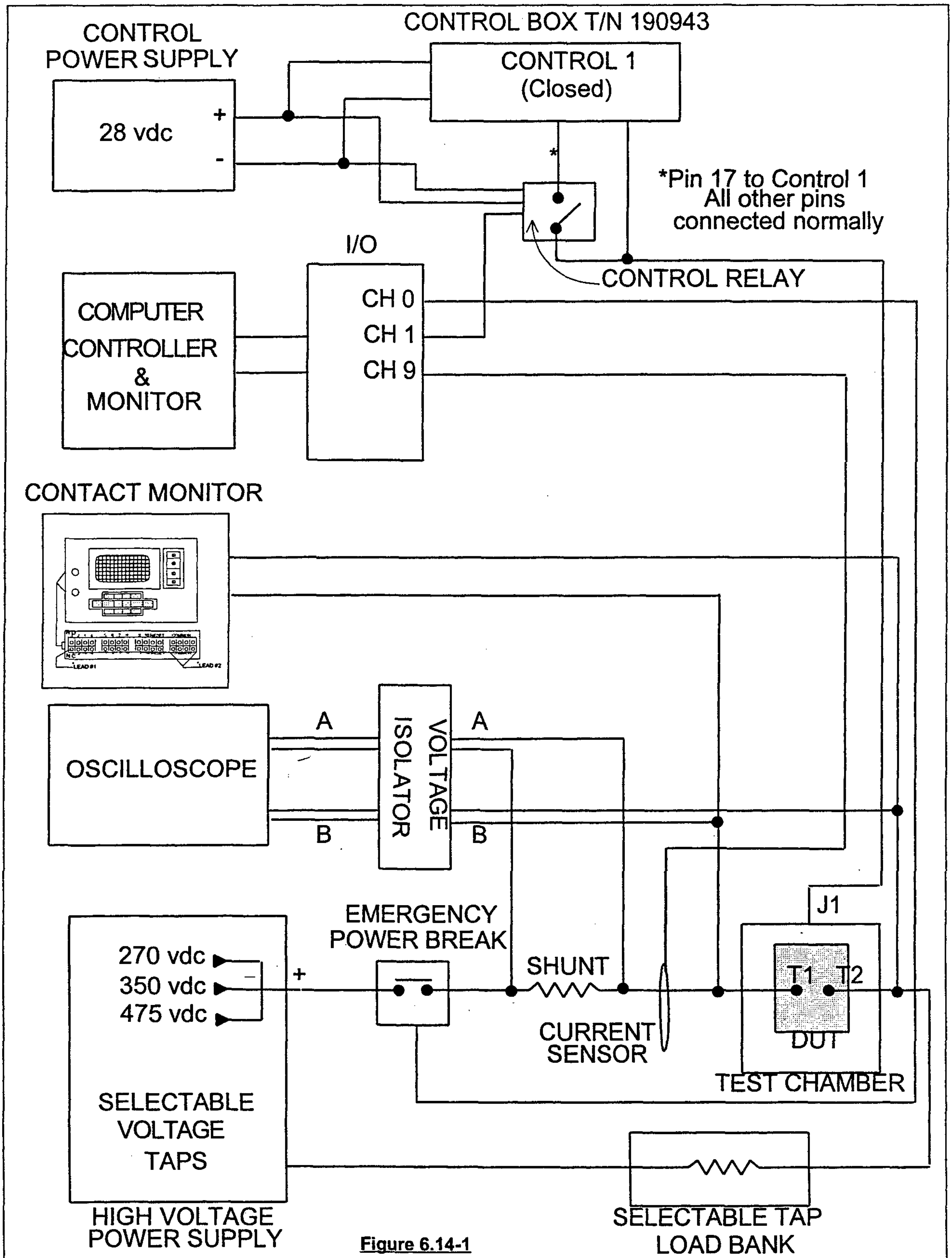
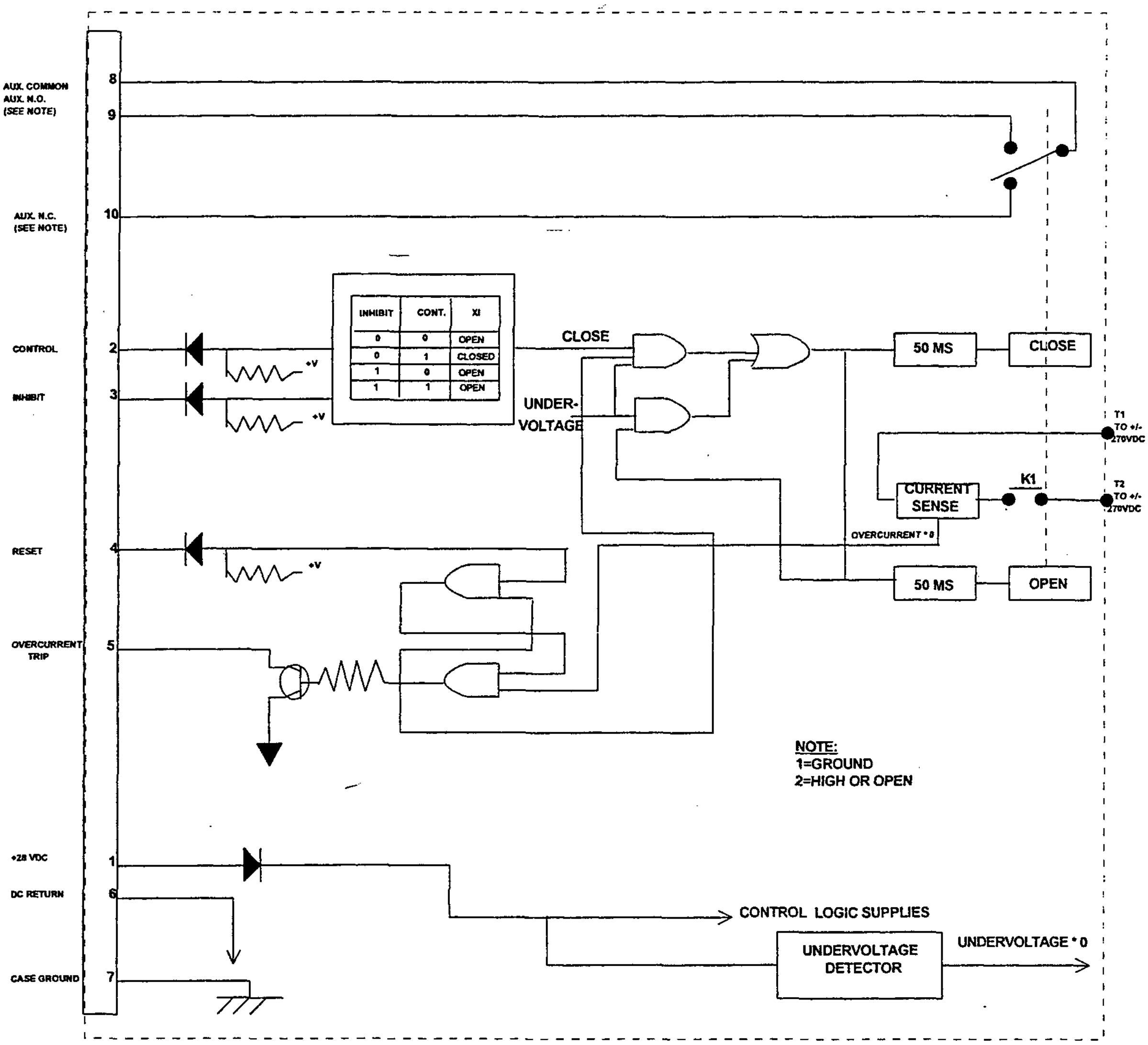


Figure 6.14-1

Electrical @ Altitude, Test Setup

APPENDIX B-A

LOGIC DIAGRAM



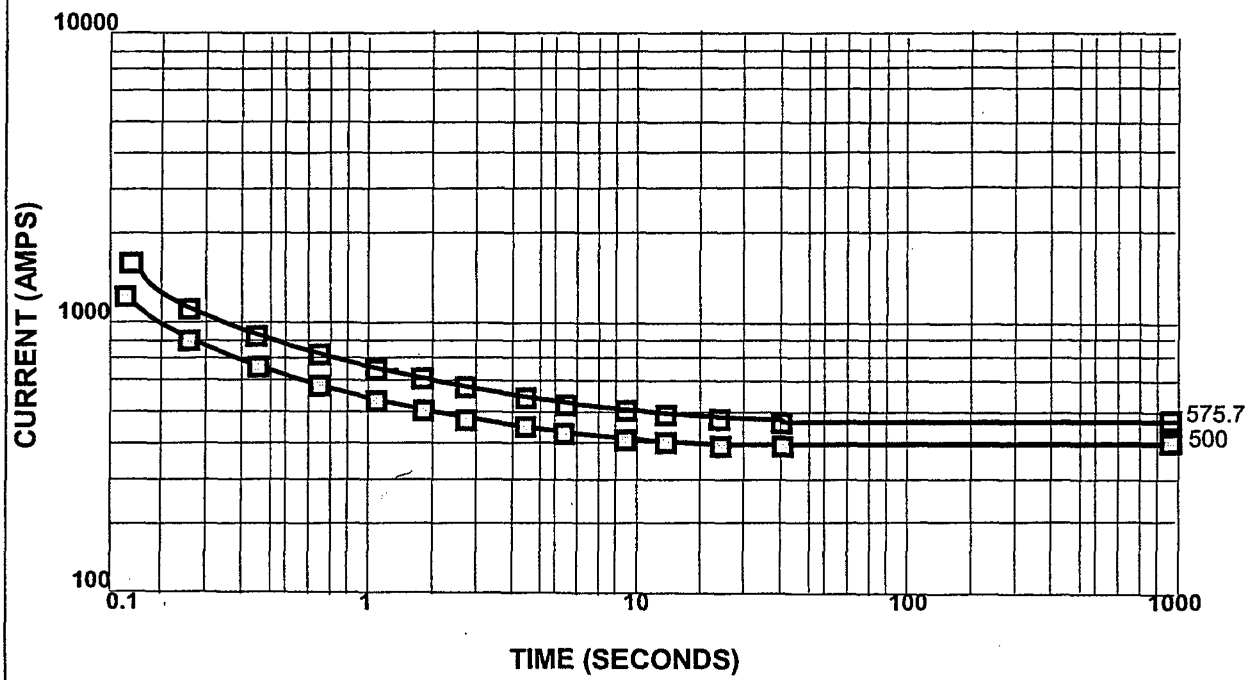
NOTE: AUXILIARY CONTACT "NORMAL" POSITION IS WITH REFERENCE TO MAIN CONTACTS IN CLOSED POSITION.

LOGIC DIAGRAM

APPENDIX B-B

500 AMP BUS TRIP CURVE

WPAFB 500 AMP TRIP CURVE

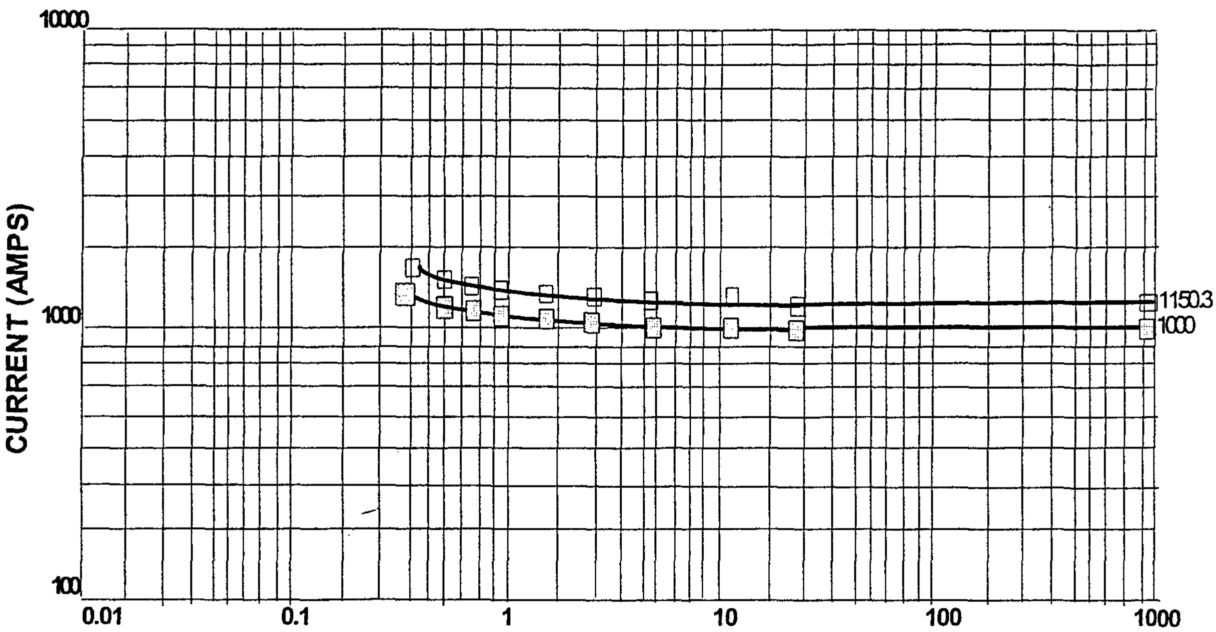


K=300,000 TOLERANCE =+7%

APPENDIX C-C

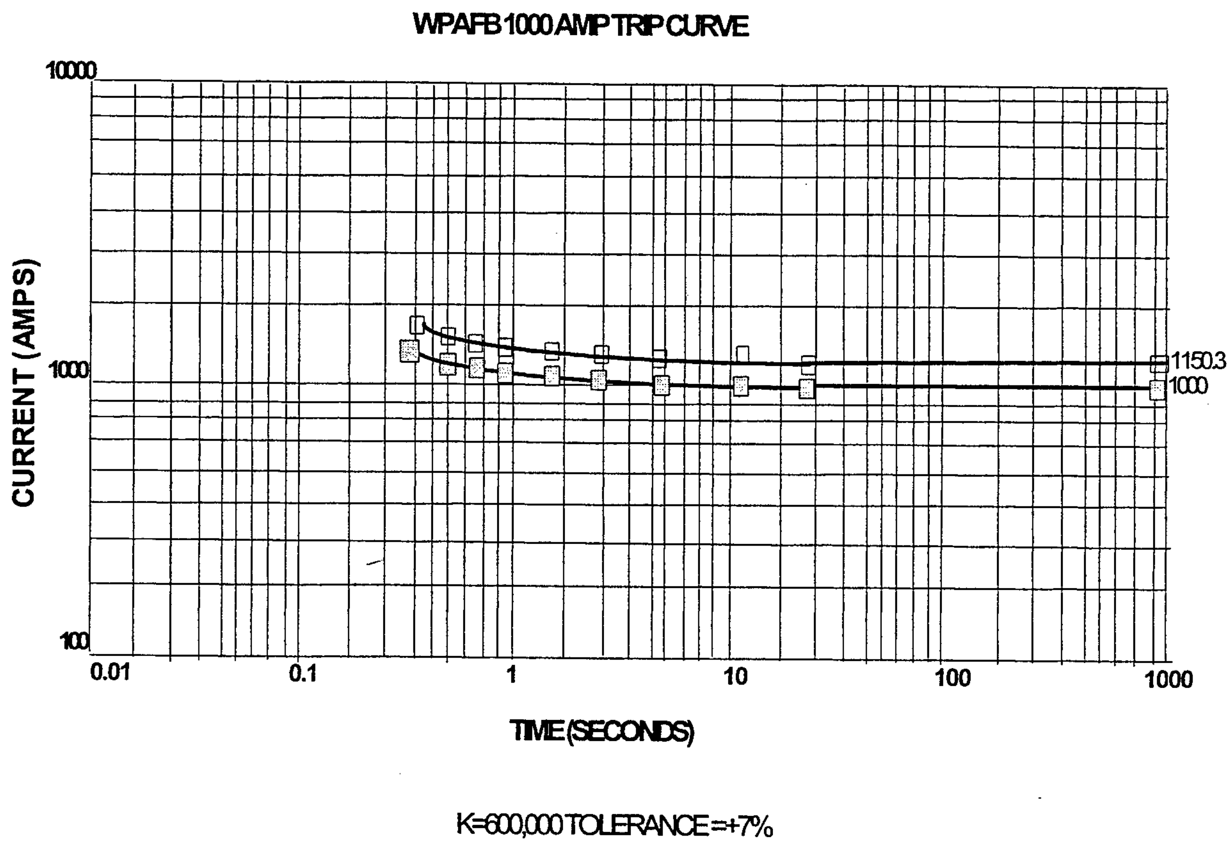
1000 AMP BUS TRIP CURVE

WPAFB 1000 AMP TRIP CURVE



TIME (SECONDS)

K=600,000 TOLERANCE=+7%


WPAFB 1000 AMP TRIP CURVE
10000
1000
100
CURRENT (AMPS)
0.01
0.1
1
10
100
1000
1150.3
1000
TIME (SECONDS)
K=600,000 TOLERANCE=+7%